



BUILDING ENVELOPE SOLUTION SETS (v 1.0) FOR ECO-NIWAS SAMHITA 2018

(Energy Conservation Building Code for Residential Buildings)
FOR EXTERNAL WALLS, ROOF, WINDOW SHADING, AND GLAZING





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(ENERGY CONSERVATION BUILDING CODE FOR RESIDENTIAL BUILDINGS)
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BUREAU OF ENERGY EFFICIENCY (BEE)
(Ministry of Power, Government of India)
Website: www.beeindia.gov.in



BUILDING ENVELOPE SOLUTION SETS (v 1.0) FOR ECO-NIWAS SAMHITA 2018

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BUREAU OF ENERGY EFFICIENCY

Abhay Bakre

Saurabh Diddi

Akanksha Krishan

Shatakshi Suman

Meenal Anand

Vineet Mall

Meenakshi Sinha

Pankaj Sharma

SWISS AGENCY FOR DEVELOPMENT AND COOPERATION (SDC), INDIA

Johnathan Demenge

Anand Shukla

INDO-SWISS BUILDING ENERGY EFFICIENCY PROJECT (BEEP) PROJECT MANAGEMENT AND TECHNICAL UNIT (PMTU)

GREENTECH KNOWLEDGE SOLUTIONS PVT. LTD

Sameer Maithel

Prashant Bhanware

Vasudha Sunger

Saswati Chetia

Vernica Prakash

ASHOK B LALL ARCHITECTS

Ashok B Lall

Salil Mohan

EFFIN'ART SARL

Pierre Jaboydeoff



Bureau of Energy Efficiency
(Ministry of Power, Government of India)

ABHAY BAKRE

Director General, Bureau of Energy Efficiency



India's building sector has generally been booming for the past several years. The residential building sector has been contributing substantially to the overall growth of the building sector. So much so that the residential building sector is slated to increase by 2.5 times (in terms of floor area) by 2030 from the 2017 level. Such trends in growth will have a tremendous impact on the energy sector, both production and consumption of energy, and, consequently, on the environment as well.

Almost 25% of the total energy consumed in the country is by the residential sector. By 2030, this sector is slated to consume about 37% of the total electricity consumption, due to increasing construction activities and increasing affordability of air-conditioning appliances.

In continuation of the larger vision of energy conservation, and with the aim of improving thermal comfort and energy conservation in residential buildings, the BEE came up with the Energy Conservation Code for Residential Buildings, *EcoNiwas Samhita* (ENS), Part I- Building Envelope in 2018. This code, which is voluntary in nature, has set minimum building envelope performance standards to limit heat gains (for cooling dominated climates) and to limit heat loss (for heating dominated climates), as well as for ensuring adequate natural ventilation and daylighting potential. In other words, the focus of ENS, Part I was on making the building envelope design energy efficient by evaluating the Residential Envelope Transmittance Value (RETV) of buildings and suggesting a combination of strategies for windows, walls and roof to achieve compliance. Needless to say, this initiative received wide acceptance and appreciation from all stakeholders.

The current guidebook (*Building Envelope Solution Sets for Eco-Niwas Samhita 2018*) goes a step further by listing out all possible options of external shading devices available in India to make that transition happen. Among the choices (with pricing information) available to you, you could select the appropriate ones that facilitate compliance with RETV values with respect to windows. I would urge all architects and developers to incorporate the strategies advocated in the manual which is the only way to mainstream energy-efficient building design and construction practices.

The Indo-Swiss Building Energy Efficiency Project (BEEP) has been instrumental in developing several such guideline documents related to building energy efficiency. BEE would like to thank the Swiss Agency for Development and Cooperation, BEEP's partner organisations in Switzerland (Effin'art Sarl) and in India (Greentech Knowledge Solutions Pvt. Ltd), BEE officials, and all other stakeholders who have played pivotal roles in bringing the issue of building energy efficiency to the mainstream.

I am confident this document will be of immense value to architects, engineers, and developers in the building/construction sector in the country.

New Delhi
4th December 2021

Abhay Bakre
Director General
Bureau of Energy Efficiency



JONATHAN DEMENGÉ

Head of Cooperation and Counsellor

The Indo-Swiss Building Energy Efficiency Project (BEEP) has been a landmark bilateral cooperation project between the governments of Switzerland and India since 2011. Together with Swiss and Indian partners, the Swiss Agency for Development and Cooperation (SDC) – has attempted to build on Switzerland's four decades of experience to co-develop knowledge and expertise on energy efficient building design, technologies, and policies in India. The development of the Eco-Niwas Samhita (ENS) 2018 (Part 1 – Building Envelope) is an important milestone, which consecrates the success of this cooperation between SDC and the Bureau of Energy Efficiency (BEE).

Keeping long-term impacts in mind, the ENS 2018 had to be declined into practical and directly implementable solutions. This is why BEEP has developed this guide to present building envelope solution sets with the aim of helping building designers in the adoption of ENS 2018 on the ground.

Building Envelope Solution Sets (v. 1.0) for EcoNiwas Samhita 2018 has come out as a supplementing document that will help achieve the Residential Envelope Transmittance Value (RETV) for building envelope as per ENS. It contains solution sets for four climatic zones (composite, hot-dry, warm-humid and temperate) to help meeting the code requirements on reducing heat gains from the building envelope, and to help users make an informed choice on how to best meet building-envelope-related code provisions in specific cases. This guide also carries cost analysis as per the Building Schedule of Rates (2019) of the Central Public Works Department (CPWD).

The success of any development cooperation project lies in its effective implementation on the ground. Based on Swiss experience, we have learned that practitioners hold the key to the successful implementation and adoption of a code. BEEP has been successfully supporting BEE in

the implementation of ENS in three states, namely Gujarat, Rajasthan, and Andhra Pradesh. We hope that practitioners in other states will also find this document practically useful to the cause that we are all wedded to: reduce the energy consumption in the residential building sector in India.

We sincerely thank the BEEP Team for making things happen!

New Delhi
4th December 2021

Jonathan Demenge, PhD
Head of Cooperation and Counsellor
Swiss Cooperation office India, Embassy of Switzerland, New Delhi



Bureau of Energy Efficiency
(Ministry of Power, Government of India)

SAURABH DIDI

Director



Government of India launched Eco-Niwas Samhita (ENS) 2018 (Part -1 Building Envelope), which is energy conservation building code for residential buildings. The code defines provisions for building envelope to reduce heat gain/loss and improve natural ventilation and daylighting potential. To facilitate the implementation of the ENS and provide assistance to concerned stakeholders, a reference booklet – titled *Building Envelope Solution Sets (v 1.0) for Eco-Niwas Samhita 2018* – has been developed. This booklet serves as a ready-reckoner by providing solutions based on real-life practices to meet the requirements related to building envelope.

Many individuals and professionals from the field have contributed handsomely to the development process of this booklet. Some wore the hat of a guide, some as supporters in various ways, some as facilitators, some as reviewers, some as information providers, and some as researchers and writers. While wholeheartedly acknowledging the immense contributions of all, the Bureau of Energy Efficiency (BEE) would like to take the names of a few who were closest to the task of producing this document.

Mr Abhay Bakre, Director General, Bureau of Energy Efficiency, provided guidance to the core development team. BEE gratefully acknowledges the support by Mr. C.K. Varma of CPWD for his observations and suggestions on the document. The role of my colleagues, Ms Akanksha Krishan, Ms Meenal Anand, Ms Shatakshi Suman, Mr Vineet Mall, Ms Meenakshi Sinha and Mr Pankaj Sharma deserves special mention.

The core development team of the Indo-Swiss Building Energy Efficiency Project (BEEP) had worked really hard to ensure that the content presented in the booklet is of top quality and relevant to the building construction industry. The undying smiles on the faces of Mr Pierre Jaboyedoff of Effin 'Art Sarl, Switzerland (Swiss Project Management Technical Unit [PMTU] and Dr Sameer Maithel, Mr Prashant Bhanware, Ms Vasudha Sunger, Ms Vernica Prakash, and Ms Saswati Chetia from Indian PMTU say it all! Kudos to all of them for a job well done!

BEE is grateful to Ashok B Lall Architects for doing a meticulous technical job with respect to the content of this booklet.

BEE would like to thank the officials of the Swiss Agency for Development and Cooperation (SDC), India – Ms Marylaure Crettaz, former Head of Co-operation and Counsellor, Swiss Co-operation office India, Embassy of Switzerland; Dr Johnathan Demengue, current Head of Co-operation and Counsellor, Swiss Co-operation office India, Embassy of Switzerland; and Dr Anand Shukla, Senior Advisor on Energy – for their constant engagement and in making available necessary technical support.

We sincerely hope that this publication serves as handy solution provider to all stakeholders.

New Delhi

4th December 2021

Saurabh Diddi

Director, Bureau of Energy Efficiency

HOW THIS DOCUMENT CAN HELP IN MEETING ENS PROVISIONS?

The Eco-Niwas Samhita 2018 or Energy Conservation Building Code for residential buildings (ECBC-R), Part I: Building Envelope defines the provisions for the following:

- 1. for natural ventilation potential¹;
- 2. for daylight potential²;
- 3. to limit heat gain/loss from the roof;
- 4. to limit heat gain from the building envelope (excluding roof) in four climatic zones (composite, hot-dry, warm-humid, and temperate); and
- 5. to limit heat loss from the building envelope (excluding roof) in cold climatic zone³.

Out of the above listed provisions, **the building envelope solutions sets for Eco-Niwas Samhita 2018 (v 1.0) helps in meeting two provisions of the code:**

- 1. **Maximum value of thermal transmittance of roof (U_{roof}) for all climate zones**

¹ A minimum value of openable window-to-floor area ratio (WFR_{op}) for each climate zone is defined. Hence, based on the climatic zone, minimum WFR_{op} can be taken from Table 1 of the code document. Multiplying this value with the carpet area, gives the value of minimum openable area for code compliance. If a project has lesser openable area, then it must be increased to meet the minimum requirement. An example of WFR_{op} calculation is given in code document.

² A minimum visible light transmittance (VLT) for different range of window-to-wall ratio (WWR) is defined. An example is given in the code document for the calculation of WWR. Based on the WWR, the minimum visible light transmittance (VLT) value can be taken from Table 2 of the code document. Selection of glazing with a VLT value that meets this requirement ensures compliance to the code.

³ A maximum value of thermal transmittance for building envelope (except roof) ($U_{envelope,cold}$) is defined as 1.8 W/m².K. $U_{envelope,cold}$ depends on the U-value of wall, the U-value of window, and WWR. Wall construction and glazing selection with low U-value helps in meeting this requirement. An example is given in the code document for the calculation of $U_{envelope,cold}$.

To limit heat gain/loss from the roof, a maximum value of thermal transmittance of roof (U_{roof}) for all climate zones is defined as 1.2 W/m².K.

This document gives roof construction solutions to help meet the requirement of U_{roof} given in the code document.

- 2. **Maximum value of residential envelope transmittance value (RETV) for building envelope (except roof) for four climatic zones (composite, hot-dry, warm-humid, and temperate)**
To limit heat gain from the building envelope (excluding roof) in four climatic zones (composite, hot-dry, warm-humid, and temperate), a maximum value of residential envelope transmittance value (RETV) for building envelope (except roof) is defined as 15 W/m². RETV depends on multiple parameters, which includes orientation, wall construction (U-value of wall), glazing properties (U-value and solar heat gain coefficient [SHGC]), WWR, and shading of windows.

This document gives the solution for wall construction, window shading, and glazing options. A combination of these solutions will most likely help the user to make an informed choice on how to best meet the RETV requirement as per ENS Part 1 for a particular building.

USING THE DOCUMENT

The solutions given in this document are classified into three main categories: Roof Construction, Wall Construction, and Window Shading and Glazing. Each solution contains some standard information, such as general description, detailed drawings, steps of construction, technical specifications, and cost analysis as per CPWD's building schedule of rates.

In the case of external shading, the solution specifies the optimum projection factor (PF) value to comply with the RETV provision of the ENS code, external shading device type, and material options and a typical MS framework cost (cost/m²) for installation purposes.

For external glazing, the solution specifies the relevant glazing technical specifications for each option and the cost per m², including a typical framing cost for each glazing option.

RESULT AND IMPACT ON A SAMPLE PROJECT

To understand the impact of these solution sets on the RETV in different climatic zones and impact on the construction cost, an example with these results is given in a tabular format. These results are specific to the selected project and will vary significantly based on the building design. Hence, the readers are advised to consider these values as indicative and carry out the calculations for their respective projects; that is, The wall solutions are placed in decreasing order of their U-Value. The first option has the maximum U-Value while the last option has the lowest U-Value

Example Project Brief: The example project given in the code document is considered here. It is a 7-storey affordable housing project. The building block has longer sides facing North-South orientation and has a WWR of 14% (Please refer to the code document for further details.). However, some key changes have been considered, which includes:

- 230-mm brick wall is considered in the baseline case;
- no shading is considered in the baseline case; and
- no opaque component is considered in the window.

The matrix table lists the impact of a combination of walling, shading, and glazing solutions stated in the document on the RETV and construction costs (incremental values in comparison to the baseline). In all, 18 options are listed in decreasing order of their U-values (starting from Wall Solution 2, which has the highest U-value out of all wall solutions).

Table 1: Impact of solution sets on RETV and construction cost

Case	Building envelope parameters			Increase in project construction cost compared to baseline [#] (%)	RETV* (W/m ²)	
	External wall	Window shading	Glazing		Composite/hot-dry climate with latitude $\geq 23.5^\circ\text{N}$ (e.g., Delhi)	Warm-humid climate with latitude $< 23.5^\circ\text{N}$ (e.g., Chennai)
Baseline	230-mm Solid burnt clay brick	No shading	Single clear	0.0	18.09	15.73
Option 1	Wall solution 2	Window shading to achieve a PF of ~ 0.4 - 0.5 where shading device is to be decided based on the location. (Below or above TOC)	Single clear	0.8	11.73	10.17
Option 2	Wall Solution 2		Single reflective	1.0	10.25	8.77
Option 3	Wall solution 2		High performance glass	1.1%	8.50	7.23
Option 4	Wall solution 5	Window shading to achieve a PF of ~ 0.4 - 0.5 where shading device is to be decided based on the location. (Below or above TOC)	Single clear	1.9%	11.26	9.77
Option 5	Wall solution 5		Single reflective	2.0%	9.78	8.36
Option 6	Wall solution 5		High performance glass	2.1%	8.03	6.83
Option 7	Wall solution 6	Window shading to achieve a PF of ~ 0.4 - 0.5 where shading device is to be decided based on the location. (Below or above TOC)	Single clear	-0.5%	10.17	8.85
Option 8	Wall solution 6		Single reflective	-0.4%	8.69	7.44
Option 9	Wall solution 6		High performance glass	-0.3%	6.94	5.91
Option 10	Wall solution 1	Window shading to achieve a PF of ~ 0.4 - 0.5 where shading device is to be decided based on the location. (Below or above TOC)	Single clear	2.8%	9.46	8.24
Option 11	Wall solution 1		Single reflective	2.9%	7.98	6.83
Option 12	Wall solution 1		High performance glass	3.0%	6.23	5.30

Case	Building envelope parameters			Increase in project construction cost compared to baseline# (%)	RETV* (W/m ²)	
	External wall	Window shading	Glazing		Composite/hot-dry climate with latitude ≥ 23.5°N (e.g., Delhi)	Warm-humid climate with latitude < 23.5°N (e.g., Chennai)
Option 13	Wall solution 3	Window shading to achieve a PF of ~0.4-0.5 where shading device is to be decided based on the location. (Below or above TOC)	Single clear	3.5%	9.22	8.04
Option 14	Wall solution 3		Single reflective	3.6%	7.74	6.63
Option 15	Wall solution 3		High performance glass	3.7%	5.99	5.10
Option 16	Wall solution 4	Window shading to achieve a PF of ~0.4-0.5 where shading device is to be decided based on the location. (Below or above TOC)	Single clear	6.8%	9.32	8.12
Option 17	Wall solution 4		Single reflective	6.9%	7.84	6.71
Option 18	Wall solution 4		High performance glass	7.0%	6.08	5.18

#The baseline construction cost has been taken from CPWD PAR (Plinth area rates) 2019 document.

*Please note that the RETV results are specific to the selected project and will vary significantly based on the building design.

EXTERNAL WALL

SOLUTION 1: 230-MM-THICK BRICK CAVITY WALL WITH INSULATION

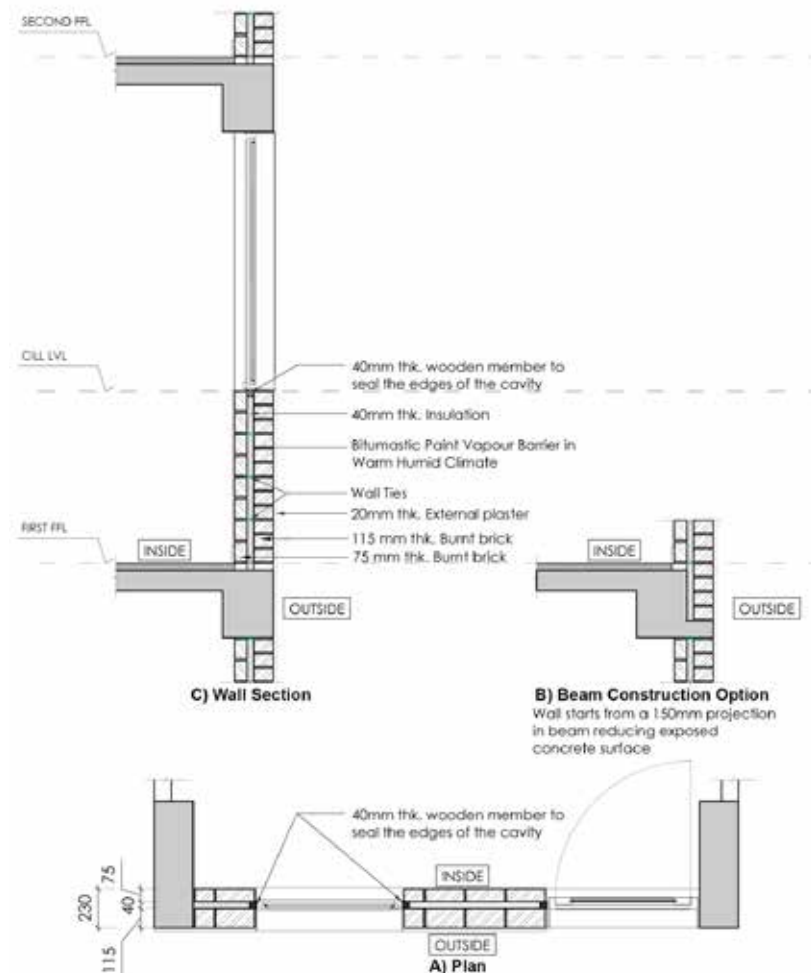
BRIEF DESCRIPTION

This wall assembly comprises a 115-mm outer wall and 75-mm inner wall with 40-mm-thick expanded polystyrene insulation* in-between two brick layers, which are held together by wall ties. This system ensures a continuous 230-mm wall thickness as in traditional method and provides better insulation. This wall is generally raised flushed to the outer surface of the slab/beam/column. Figure A provides the top view of the assembly. The construction steps are shown in Figures 1 to 6.

The exposed area of RCC structure to the outside, which can be as much as 15%–20% of the envelope wall area, remains a thermal bridge between inside and outside. To further reduce the external exposed RCC surface, one could cast the beams with a small 150-mm projection as shown in Figure B. Now the wall starts from this projection. This protects the outer surfaces of the RCC structure from conductive heat gain.

Note that the ends of the cavity where doors and windows are to be fixed need to be properly closed. This is most conveniently done by plugging these ends with a timber section (Figure C). Weep holes should be provided at the bottom of each of the outer wall at intervals.

*Alternative insulation materials such as polyurethane foam spray, polyurethane foam slab, glass wool, rock wool, and extruded polystyrene can also be used in place of expanded polystyrene insulation. However, the costing, construction steps, and U-value will be different.



ITEM DESCRIPTION FOR BOQ (Bill of Quantities)

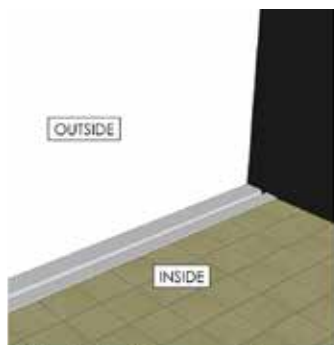
Providing and laying two brick walls simultaneously, with 115-mm-thick brick wall on the exterior face and 75-mm-thick brick wall on the interior face with 40-mm expanded polystyrene insulation, thereby making a 230-mm thick wall assembly. The inner face of the 115-mm wall is painted with bitumastic paint in warm-humid climate, which acts as a vapour barrier.

0.62 W/m².K
U-value

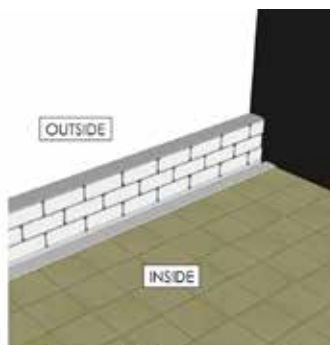
₹3050[#]
Cost/m²

[#] The cost calculations are done as per CPWD DSR 2019. The rates are likely to vary across the country. As per CPWD DSR 2019, the cost of 230-mm brick wall with finishing is ₹2400/m². It is recommended to calculate the cost based on local rates of material, labour, taxes, etc.

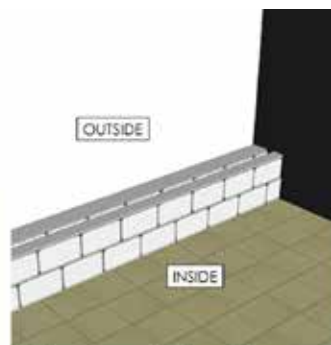
CONSTRUCTION STEPS



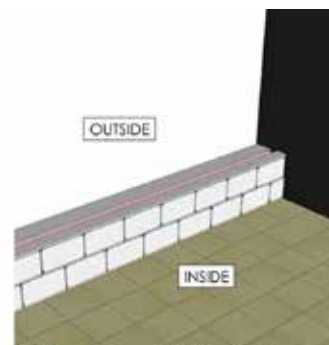
1 Laying levelling course (about 40mm) to begin brickwork from a flat surface



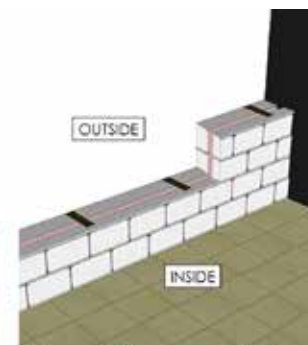
2 Start with laying 3 courses of exterior 115mm thick wall



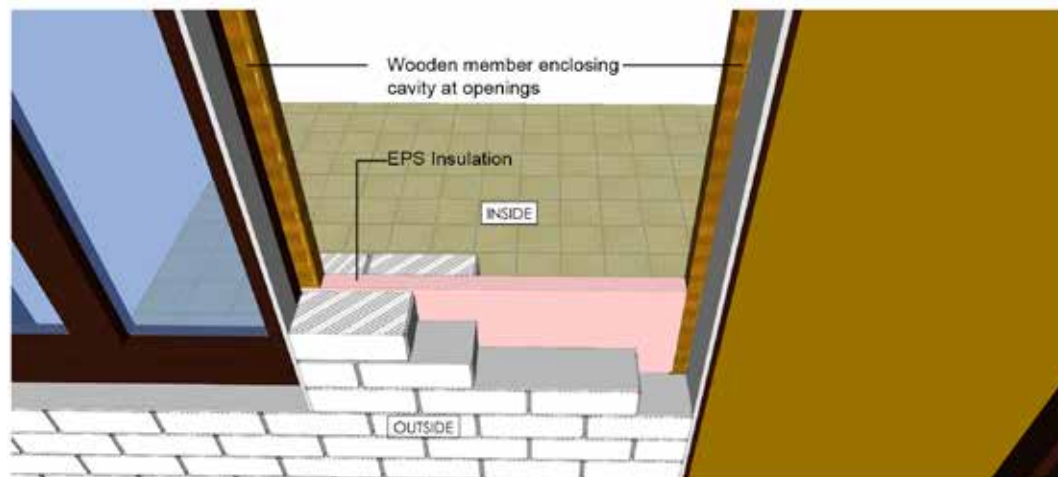
3 Leave a gap of 40mm & lay two courses of 75mm thick wall such that the top level matches for both courses



4 Insert 40mm thick insulation inside the cavity



5 Place wall ties at every 600mm distance and repeat the next set.



6 To avoid thermal bridging the cavity between the inside and outside walls should be enclosed with a wooden piece at the masonry openings for a door or window as shown in the image above.

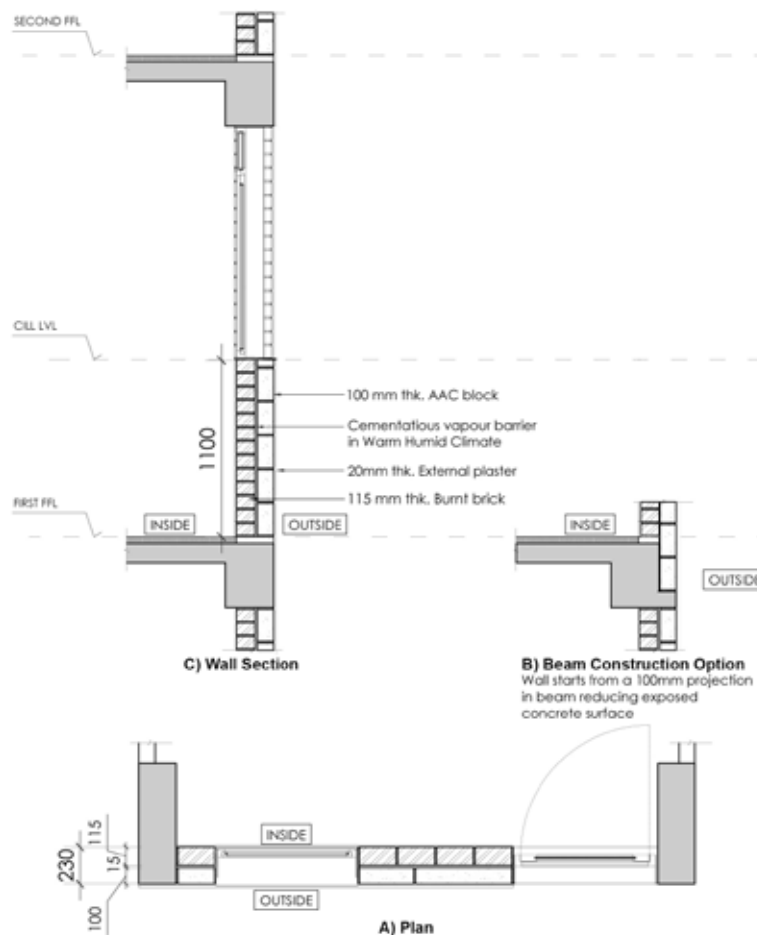


SOLUTION 2: 115-MM-THICK BRICK WALL + 100-MM-THICK AAC BLOCK

BRIEF DESCRIPTION

This wall assembly comprises a 100-mm-thick AAC blockwork outer wall and 115-mm-thick inner brick wall. The outer face of the inner wall should be painted with a bitumastic paint layer to act as a vapour barrier in warm-humid climates. The total wall assembly will be 230-mm thick. The assembly can be raised a few courses at a time, the AAC wall being raised after painting the outer surface of the brick wall with bitumastic paint. This paint also acts as an adhesive to bond the AAC blockwork to the inner wall. Figure A provides the top view of the assembly. The construction steps are shown in Figures 1 to 5.

The exposed area of RCC structure to the outside, which can be as much as 15%–20% of the envelope wall area, remains a thermal bridge between inside and outside. To further reduce the external exposed RCC surface, one could cast the beams with a small 150-mm projection as shown in Figure B. Now the wall starts from this projection. This protects the outer surfaces of the RCC structure from conductive heat gain. The details of the wall section are shown in Figure C.



ITEM DESCRIPTION FOR BOQ

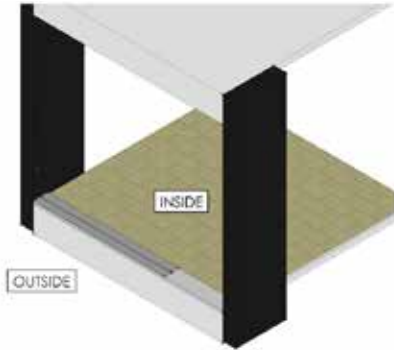
Providing and laying 100-mm-thick AAC wall on the outer face and 115-mm-thick brick wall on the inner face. The inner face of the 115-mm brick wall is painted with bitumastic paint in warm-humid climate, which acts as a vapour barrier.

1.1 W/m².K
U-value

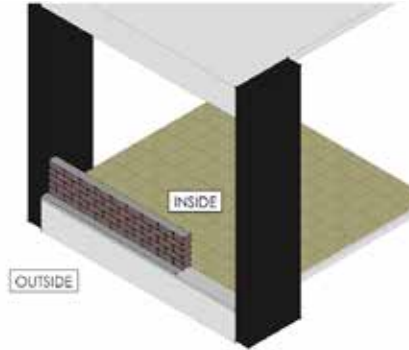
₹2400[#]
Cost/m²

[#] The cost calculations are done as per CPWD DSR 2019. The rates are likely to vary across the country. As per CPWD DSR 2019, the cost of 230mm brick wall with finishing is ₹2400/m². It is recommended to calculate the cost based on local rates of material, labour, taxes, etc.

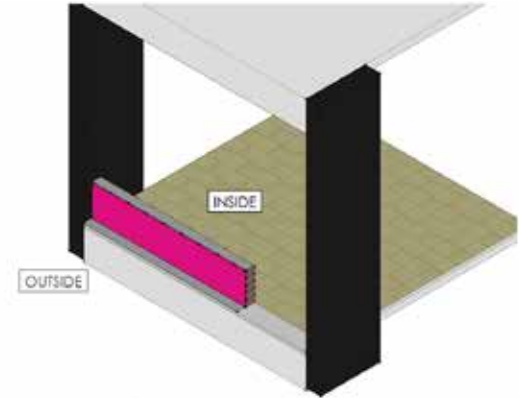
CONSTRUCTION STEPS



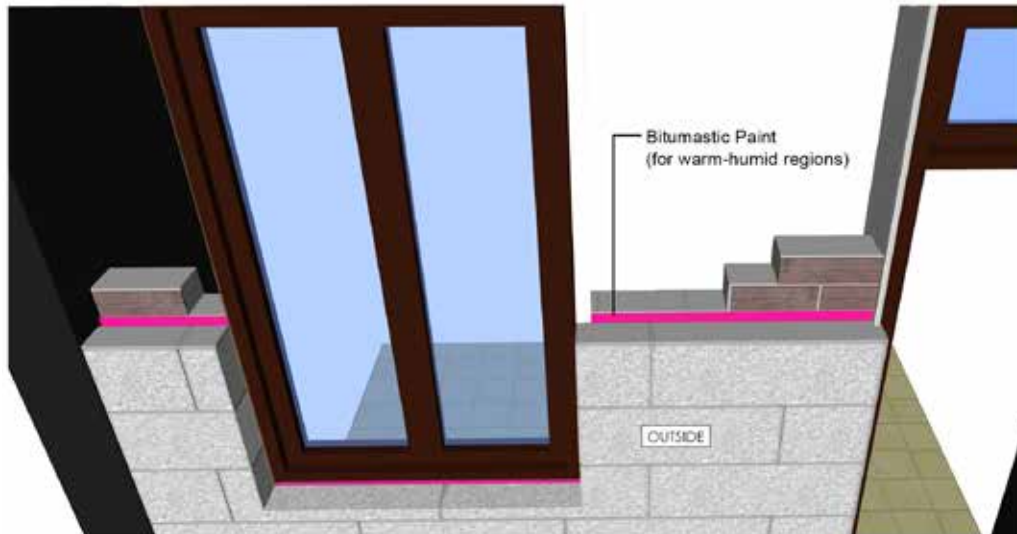
- 1** Laying levelling course (about 40mm) to begin brickwork from a flat surface



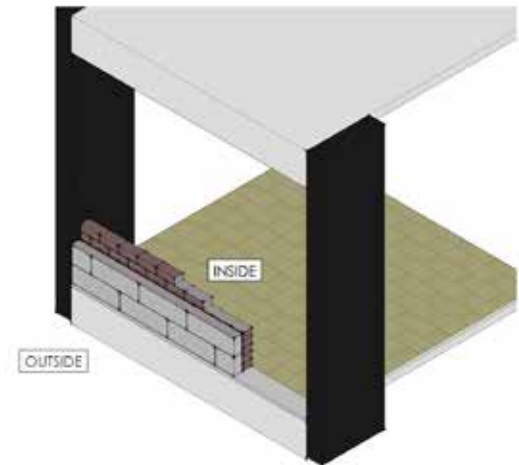
- 2** Raise the interior 115mm thick brickwall



- 3** Apply cementitious vapour barrier in warm-humid climate.



- 5** The bitumastic paint (Vapor Barrier) here also acts as an adhesive that bonds the outer AAC wall to the inner wall.



- 4** Raise the exterior 100mm thick AAC blockwork, after leaving a 15mm gap

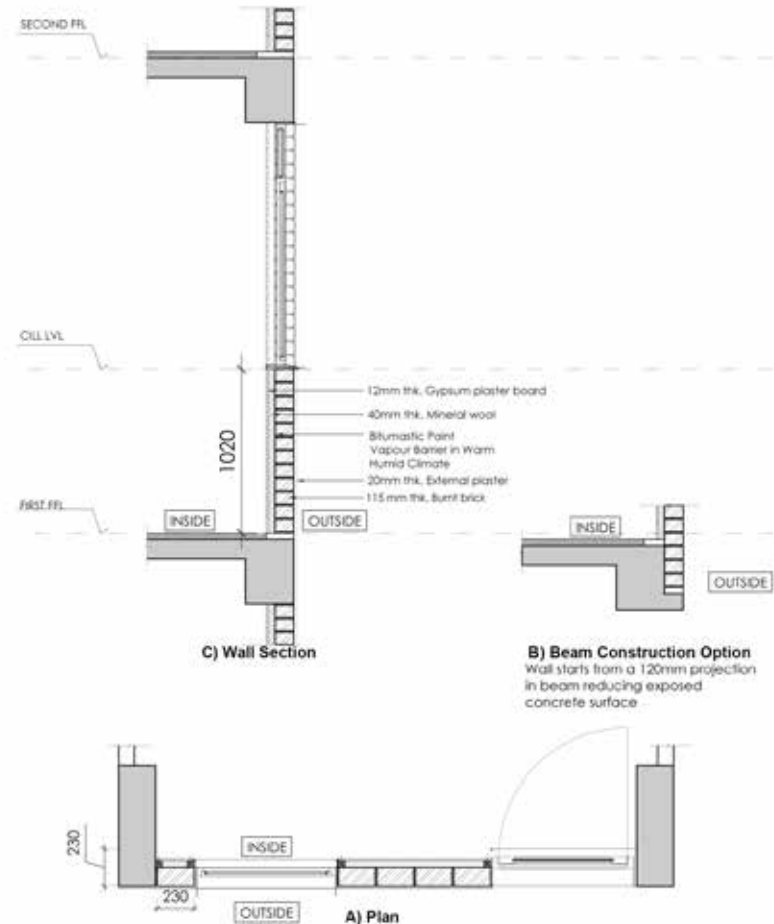
SOLUTION 3: 115-MM-THICK BRICK WALL + INSULATION ON INTERIOR FACE

BRIEF DESCRIPTION

This wall assembly comprises a 115-mm outer brick wall with insulation on the inside. The insulation material of mineral wool* may be fixed within a wooden/GI framework. Next, a gypsum plaster board is fixed onto this frame. The insulation material should cover the entire wall surface and must be tightly fitted within the framework, leaving no gaps. This is essential for the insulation to be effective. If a GI framework is used, then a nylon washer should be used to separate the framework from the wall. This avoids conduction from the wall to the GI framework. Figure A provides the top view of the assembly. The construction steps are shown in Figures 1 to 6.

The exposed area of RCC structure to the outside, which can be as much as 15%–20% of the envelope wall area, remains a thermal bridge between inside and outside. To further reduce the external exposed RCC surface, one could cast the beams with a small 120-mm projection as shown in Figure B. Now the wall starts from this projection. This protects the outer surfaces of the RCC structure from conductive heat gain. The details of the wall section are shown in Figure C.

*Alternative insulation materials such as polyurethane foam spray, polyurethane foam slab, glass wool, rock wool, and extruded polystyrene can also be used in place of expanded polystyrene insulation. However, the costing, construction steps, and U-Value will be different



ITEM DESCRIPTION FOR BOQ

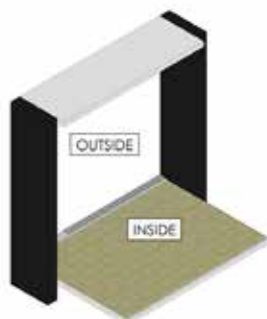
Providing and laying 115-mm-thick brick wall on exterior face. Providing 40-mm mineral wool insulation onto the interior face within a wooden framework fixed to wall. Gypsum plaster board to be fixed on the wooden framework to enclose the insulation.

0.57 W/m².K
U-value

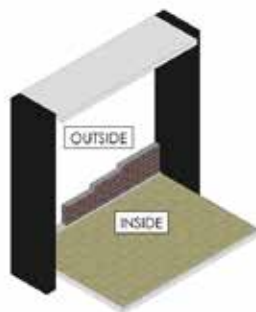
₹3300[#]
Cost/m²

[#] The cost calculations are done as per CPWD DSR 2019. The rates are likely to vary across the country. As per CPWD DSR 2019, the cost of 230mm brick wall with finishing is ₹2400/m². It is recommended to calculate the cost based on local rates of material, labour, taxes, etc.

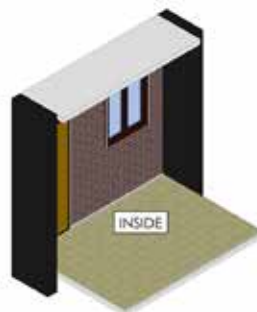
CONSTRUCTION STEPS



1 Laying Levelling course (about 40mm) to begin brickwork from a flat surface



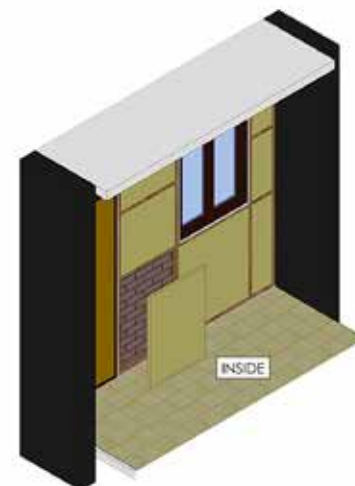
2 Start with laying the 115mm thick brick wall



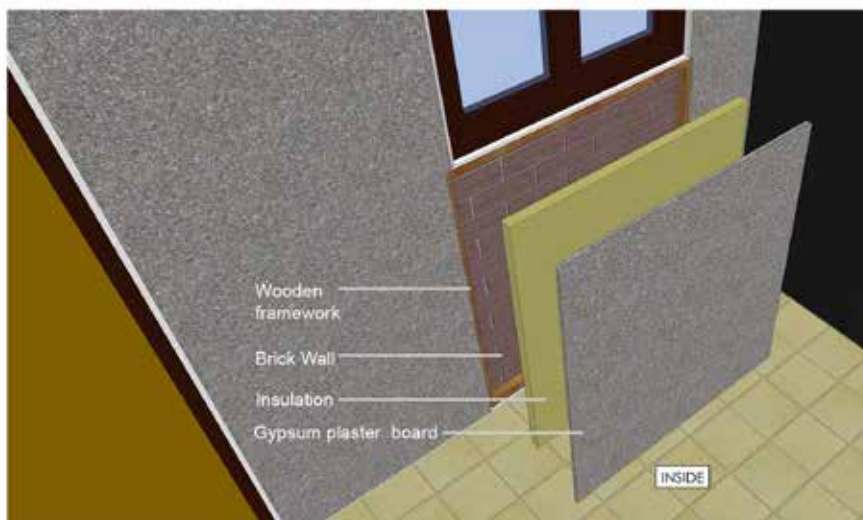
3 Complete the wall and install doors and windows



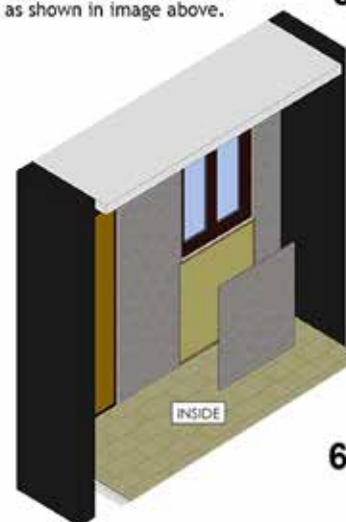
4 Fix a wooden framework to the wall as shown in image above.



5 Put insulation within the wooden framework.



Interior view of the wall assembly. To have better efficiency of the insulating material, the window and door openings should be properly sealed.

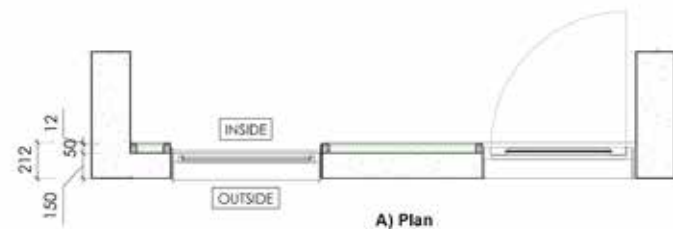
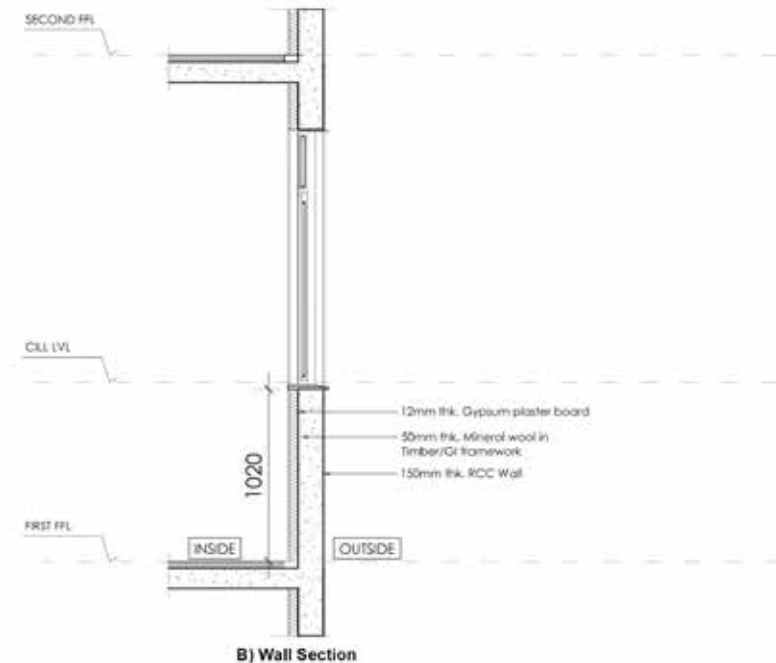


6 Fix gypsum board panel on the wooden frame to enclose the insulation.

SOLUTION 4: 150-MM RCC WALL + INSULATION ON INTERIOR FACE

BRIEF DESCRIPTION

This wall assembly comprises a 150-mm-thick RCC outer wall with insulation on the inside. The insulation material – mineral wool - can be fixed within a wooden/GI framework. Next, a gypsum plaster board is fixed onto this frame. The insulation material should cover the entire wall surface and must be tightly fitted within the framework, leaving no gaps. This is essential for the insulation to be effective. If a GI framework is used, then a nylon washer should be used to separate the framework from the wall. This avoids conduction from the wall to the GI framework. Figure A provides the top view of the assembly. The construction steps are shown in Figures 1 to 5. The details of the wall section are shown in Figure B.



ITEM DESCRIPTION FOR BOQ

Providing and making 150-mm-thick RCC wall.

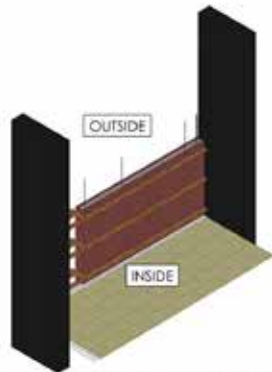
Providing and fixing 40-mm mineral wool insulation onto the interior face within a wooden/GI framework fixed to wall. Gypsum plaster board (12-mm thick) to be fixed on the wooden framework to cover the insulation.

0.59 W/m².K
U-value

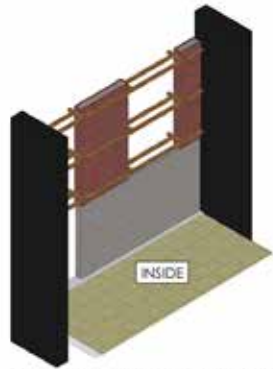
₹4400[#]
Cost/m²

[#] The cost calculations are done as per CPWD DSR 2019. The rates are likely to vary across the country. As per CPWD DSR 2019, the cost of 230-mm brick wall with finishing is ₹2400/m². It is recommended to calculate the cost based on local rates of material, labour, taxes, etc

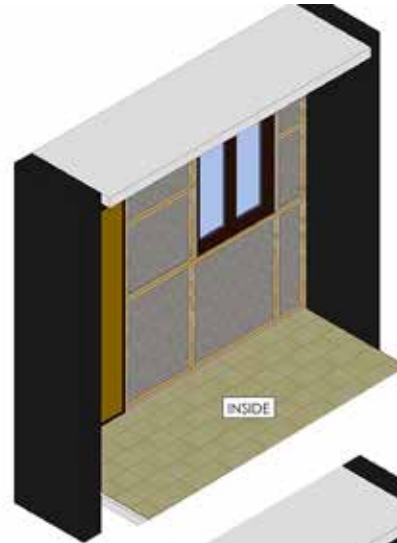
CONSTRUCTION STEPS



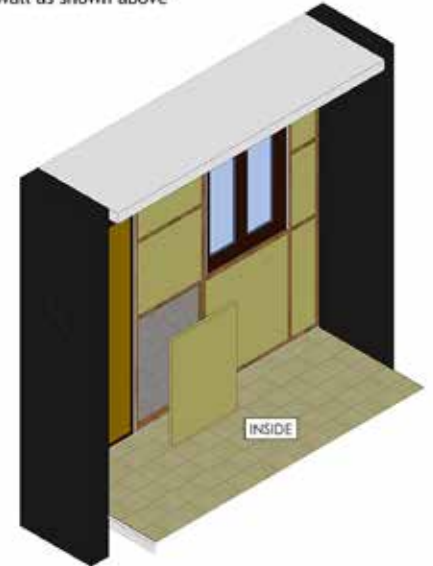
1 Laying shuttering formwork to cast concrete.



2 Providing openings for doors and windows



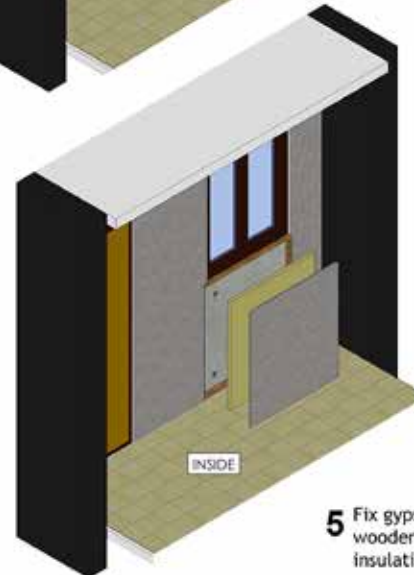
3 Fixing wooden framework to the wall as shown above



4 Put insulation within the wooden framework.



Interior view of the wall assembly. To have better efficiency of the insulating material, the window and door openings should be properly sealed.

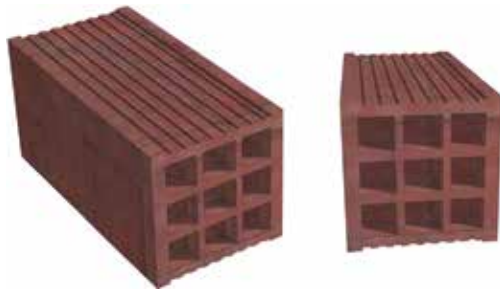


5 Fix gypsum board panel on the wooden frame to enclose the insulation.

SOLUTION 5: 200-MM-THICK HOLLOW CLAY BLOCKS

BRIEF DESCRIPTION

Hollow clay bricks generally come in 150-mm and 200-mm thickness. For the construction of the external wall, a 200-mm-thick block is recommended. These blocks have horizontal cavity that improve the thermal performance of the wall. These blocks are used for external walls and are joined with a dryfix adhesive or cement mortar between the blocks. Figure A provides the top view of the assembly. The construction steps are shown in Figures 1 to 4. The details of the wall section are shown in Figure B.

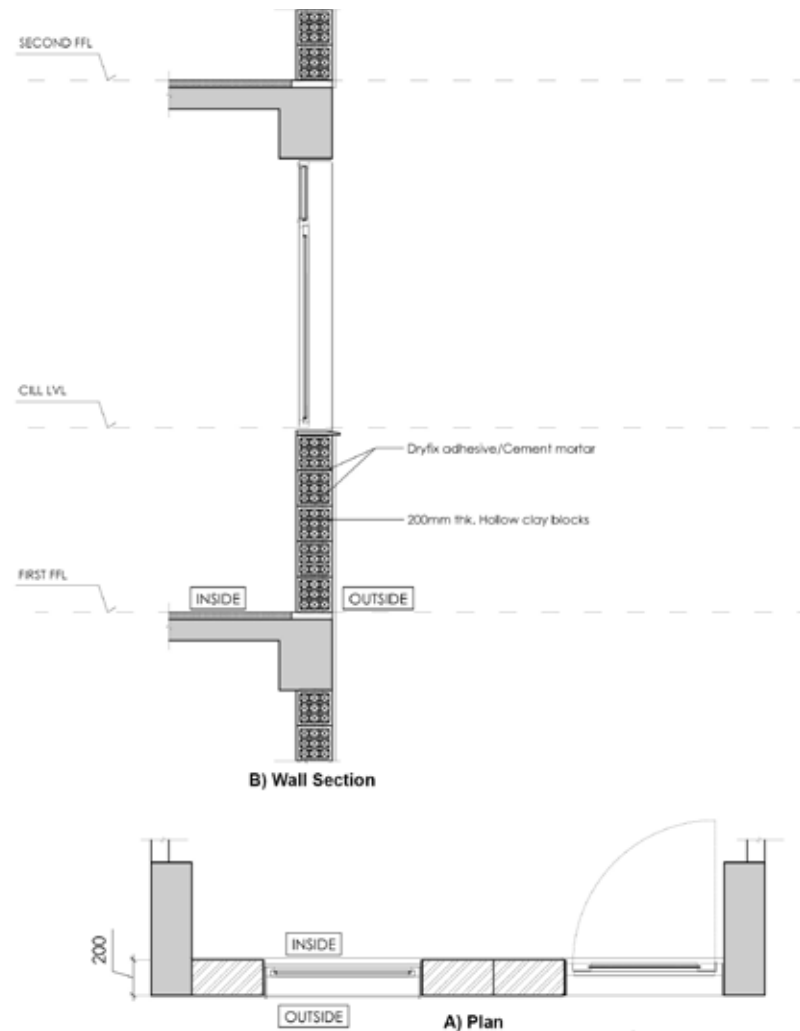


ITEM DESCRIPTION FOR BOQ

Providing and laying 200-mm-thick hollow core clay bricks with a dryfix adhesive/cement mortar between the blocks.

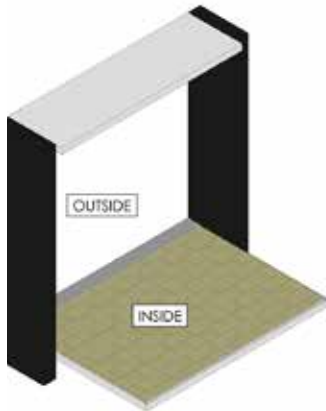
1.0 W/m².K
U-value

₹2750[#]
Cost/m²

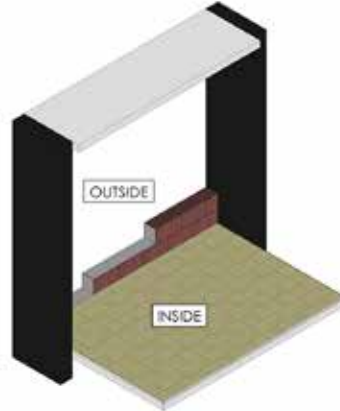


[#] The cost calculations are done as per CPWD DSR 2019. The rates are likely to vary across the country. As per CPWD DSR 2019, the cost of 230mm brick wall with finishing is ₹2400/m². It is recommended to calculate the cost based on local rates of material, labour, taxes etc.

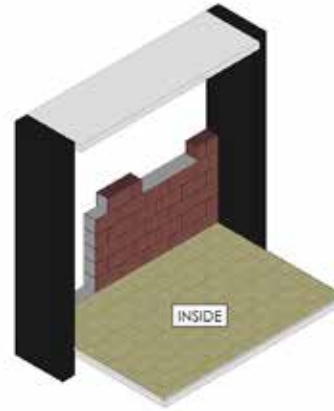
CONSTRUCTION STEPS



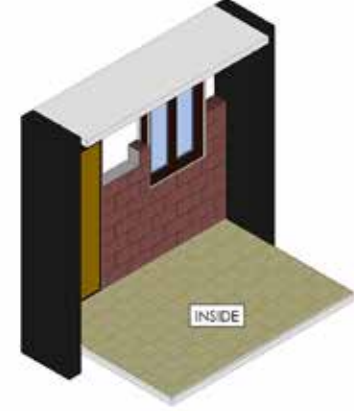
1 Laying Levelling course (about 40mm) to begin brickwork from a flat surface



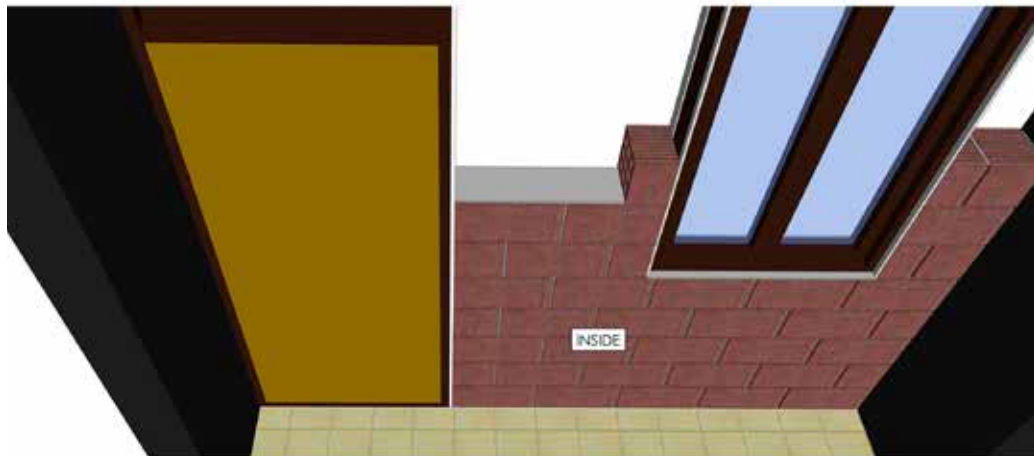
2 Laying 200mmx200mmx400mm hollow clay blocks



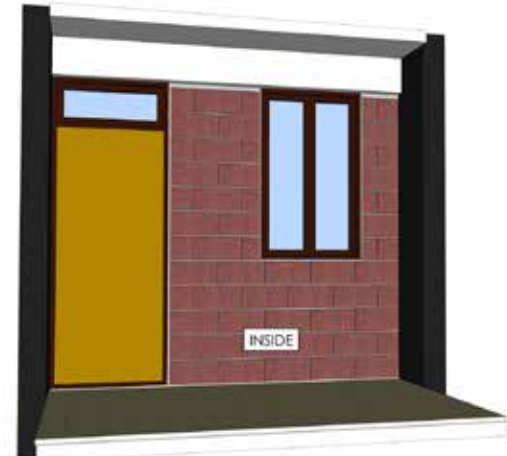
3 Raise the wall and provide openings for doors and windows



4 Fix doors and windows



Interior Elevation



Interior Elevation

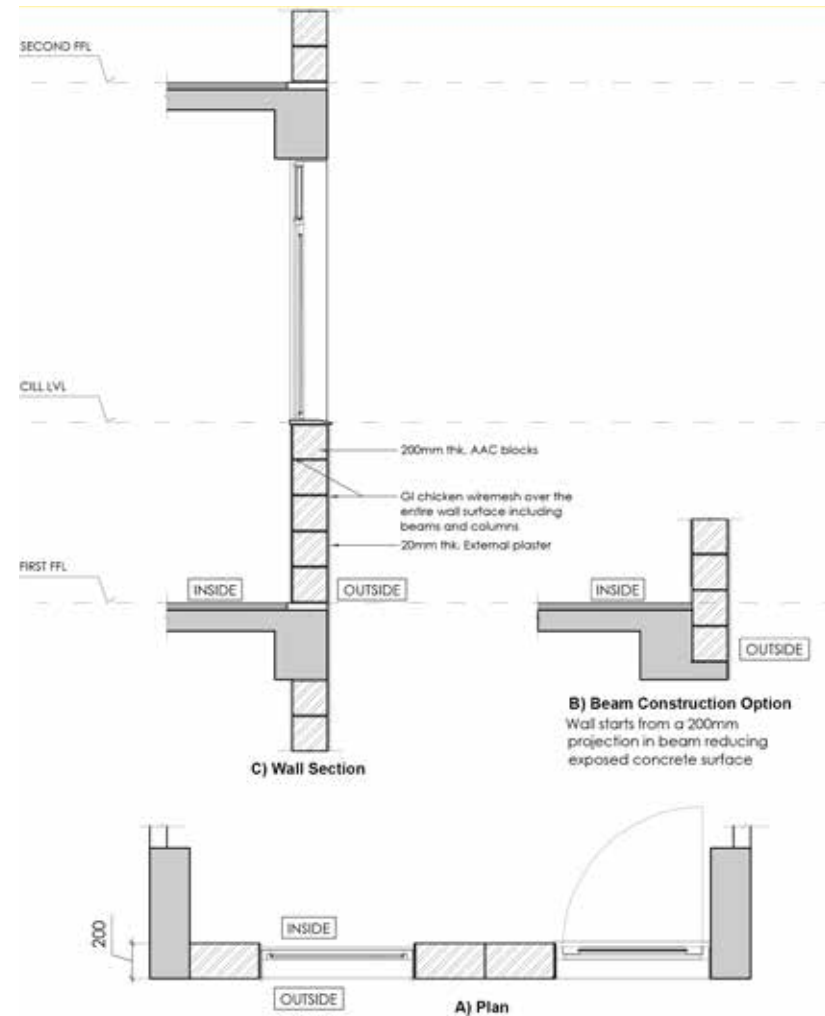
SOLUTION 6: 200-MM-THICK AUTOCLAVED AERATED CONCRETE BLOCKS

BRIEF DESCRIPTION

Autoclaved aerated concrete (AAC) block is a lightweight, load-bearing, and high insulating block that comes in various thickness of 100 mm, 150 mm, and 200 mm.

For the construction of external walls, a 200-mm-thick AAC block is recommended. For carrying out masonry work, a non-shrink grout should be added to the mortar. This should be used between the blocks as well as at all junctions of mortar and RCC work.

The internal and external surfaces of the 200-mm-thick AAC wall should be provided with a GI chicken wire-mesh over entire AAC block masonry including overlap at concrete-masonry junctions. This would help in avoiding shrinkage cracks in the future. Figure A provides the top view of the assembly. The construction steps are shown in Figures 1 to 5. The beam details are shown in Figures B. The details of the wall section are shown in Figures C.



ITEM DESCRIPTION FOR BOQ

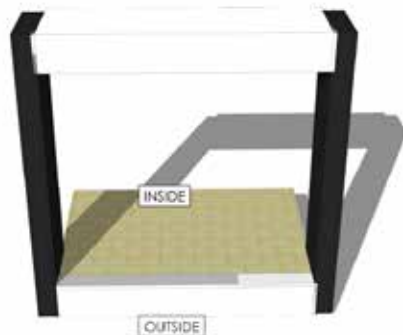
Providing & constructing AAC Block masonry conforming to IS 2185 Part 3 with approved quality factory made Grade 1 AAC blocks of dry density of 551 to 650 kg/cum, compressive strength of 4N/sq.mm, water absorption is less than 15%, thermal conductivity less than 0.24 W/m.K and as approved by EIC and approved method statement.

0.77 W/m².K
U-value

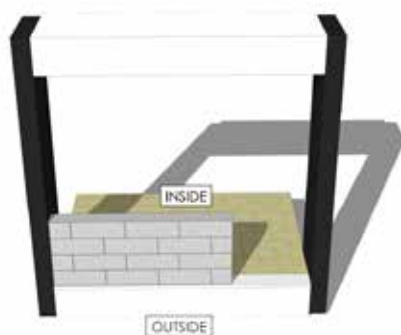
₹1950[#]
Cost/m²

[#] The cost calculations are done as per CPWD DSR 2019. The rates are likely to vary across the country. As per CPWD DSR 2019, the cost of 230mm brick wall with finishing is ₹2400/m². It is recommended to calculate the cost based on local rates of material, labour, taxes, etc.

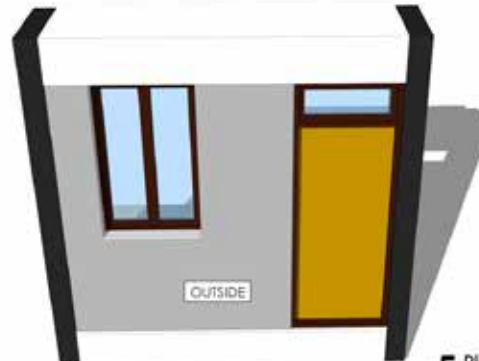
CONSTRUCTION STEPS



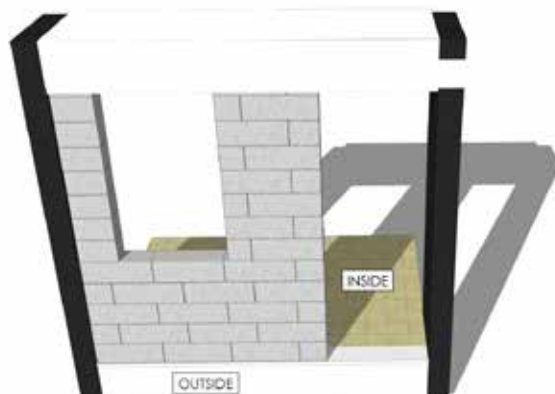
- 1** Laying levelling course (about 40mm) to begin brickwork from a flat surface



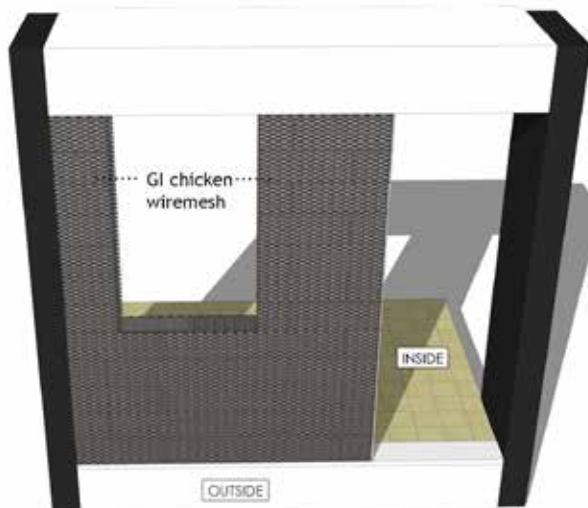
- 2** Laying 200mmx200mmx400mm AAC blocks



- 5** Plaster the wall and fix doors and windows



- 3** Raise the wall and provide openings for doors and windows



- 4** Fix GI chicken wiremesh over the entire surface of blocks and structure overlap.

ROOF

SOLUTION 1: RCC SLAB WITH 50-MM-THICK POLYURETHANE FOAM INSULATION

BRIEF DESCRIPTION

This roof assembly comprises a 50-mm-thick polyurethane foam (PUF) insulation* to reduce the conductive heat loads from the roof. First the roof surface is flattened with screed to achieve a smooth finish. Then a waterproofing membrane is applied over the entire surface. Next, the PUF insulation is put on the waterproofing layer. There should be no gap at the joints between adjacent PUF boards; this is to ensure continuity of the insulation layer. Some PUF vendors provide boards with interlocking profiles to ensure that there are no gaps between adjacent boards.

As the waterproofing layer is below the insulative layer, the insulation material should be of a closed cell structure, which does not absorb water. Fibrous insulation material that absorb water cannot be used above the waterproofing layer.

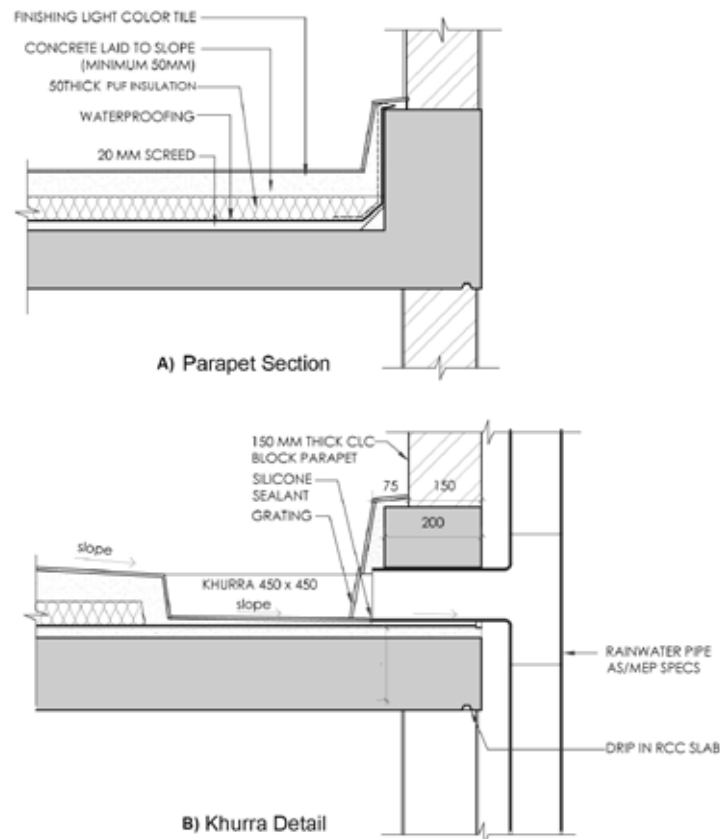
Then, to achieve the slope on the terracing, lay concrete (minimum 50 mm) over the insulation that slopes towards the Khurra of the rainwater pipes. This concrete layer is then further finished with a China mosaic/light colour tile finish. The light colour helps reflect the incident solar radiation. The joints between these tiles act as a breathable network, which helps in the evaporation of absorbed moisture. The construction steps are shown in Figures 1 to 6. Figures A and B provide details of the parapet section and Khurra, respectively.

*Alternative insulation material such as PUF spray and extruded polystyrene insulation can also be used in place of PUF insulation. However, the costing, construction steps, and U-Value will be different.

ITEM DESCRIPTION OF BOQ FOR OVERDECK INSULATION

Providing and laying roof insulation with 40-mm-thick rigid polyurethane (PU) sheet over deck insulation (density of the sheet being 36 kg/cum) and compressive strength of 172 KN/m², over a coat of PU primer applied at the rate of 6-8 m² per litre, laying 400 G (guage) polythene sheet over PUF sheet and providing a wearing course of 40-mm-thick cement screed 1:2:4 (1 cement: 2 coarse sand: 4 stone aggregate of 20-mm nominal size) in chequered rough finish, in panels of 2.5 x 2.5 m and embedding with 24 G wire-netting and sealing the joints with polymerized mastic, all complete as per the direction of the Engineer-in-Charge.

The cost calculations are done as per CPWD DSR 2019. The rates are likely to vary across the country. As per CPWD DSR 2019, the cost of 150-mm RCC roof with finishing is ₹3850/m². It is recommended to calculate the cost based on local rates of material, labour, taxes, etc. For insulation in roofing assembly, lower thickness is available, but the standard material and thickness as per the market availability is used.



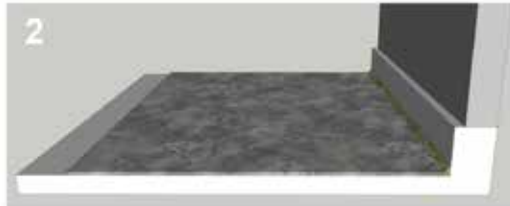
0.46 W/m².K
U-value

₹4800[#]
Cost/m²

CONSTRUCTION STEPS



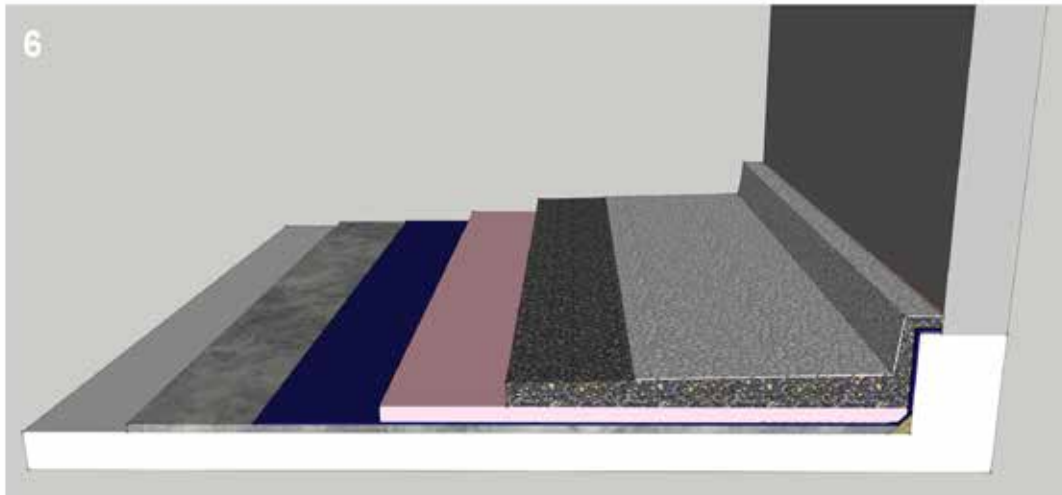
1
Triangular wedge to enable turning of waterproofing layer



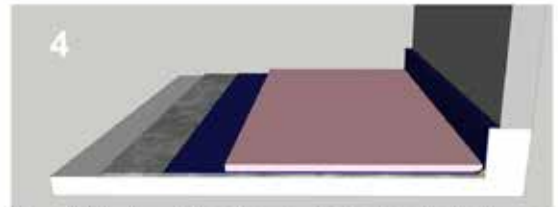
2
20mm thick screed to level the top of terrace slab



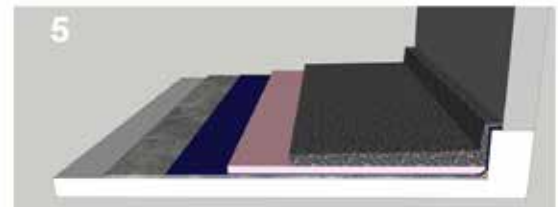
3
Waterproofing layer to turn and fold over the upturn/ terrace parapet base.



6
The finishing material is preferably light color tile to reflect solar radiation.



4
50mm thick poly urethane foam insulation boards placed over the waterproofing layer.



5
Concrete laid over insulation to achieve desired slope in terracing.

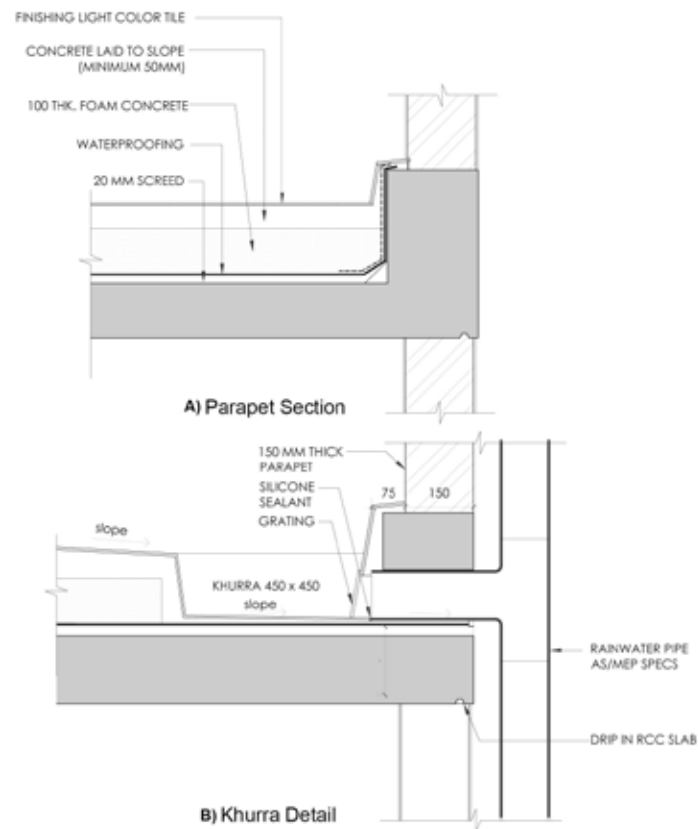
SOLUTION 2: RCC SLAB WITH 100-MM-THICK FOAM CONCRETE INSULATION

BRIEF DESCRIPTION

This roof assembly comprises a 100-mm-thick foam concrete insulation to reduce the conductive heat loads from the roof. First the roof surface is flattened with screed to achieve a smooth finish. Then a waterproofing membrane is applied over the entire surface. Next, the foam concrete insulation is put on the waterproofing layer.

As the waterproofing layer is below the insulation layer, the insulation material should be of a closed cell structure, which does not absorb water. Fibrous insulation material, which absorbs water, cannot be used above the waterproofing layer.

Then, to achieve the slope on the terracing, lay concrete (minimum 50 mm) over the insulation that slopes towards the Khurra of the rain water pipes. This concrete layer is then further finished with a China mosaic/light colour tile finish. The light colour helps reflect the incident solar radiation. The joints between these tiles act as a breathable network, which helps in the evaporation of absorbed moisture. The construction steps are shown in Figures 1 to 6. Figures A and B provide details of the parapet section and Khurra, respectively.



ITEM DESCRIPTION OF BOQ FOR OVERDECK INSULATION

Pouring 100-mm-thick foam concrete insulation over the water proofing surface having a thermal conductivity of 0.07 W/m.K, density of 320 kg/m³. The compressive strength is 0.5-1.0 N/mm² (Source: British Concrete Association). The laying is done through foam concrete pouring machine. Complete in all respect as per the direction of the Engineer-in-Charge.

0.62 W/m².K
U-value

₹4300[#]
Cost/m²

[#] The cost calculations are done as per CPWD DSR 2019. The rates are likely to vary across the country as per CPWD DSR 2019; the cost of 150-mm RCC roof with finishing is ₹3850/m². It is recommended to calculate the cost based on local rates of material, labour, taxes, etc. For insulation in roofing assembly, lower thickness is available, but the standard material and thickness as per the market availability is used.

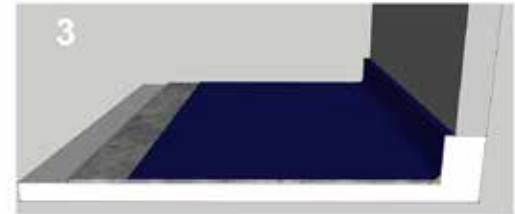
CONSTRUCTION STEPS



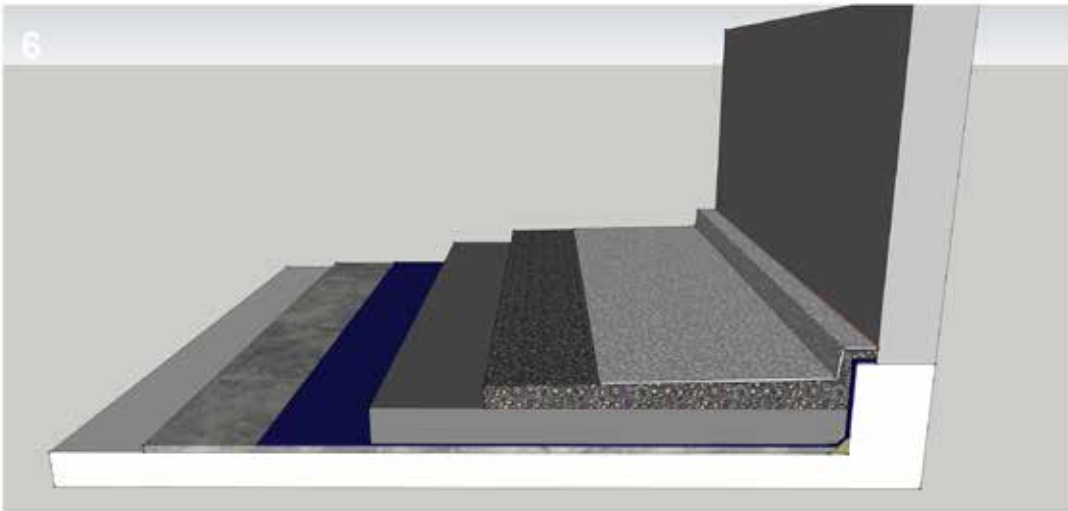
Triangular wedge to enable turning of waterproofing layer



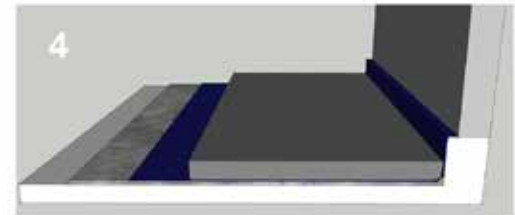
20mm thk. screed to level the top of terrace slab



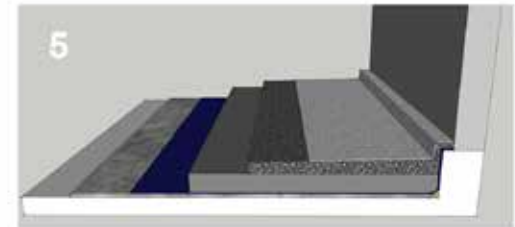
Waterproofing layer to turn and fold over the upturn/ terrace parapet base.



The finishing material is preferably light color tile to reflect solar radiation.



100mm thick foam concrete insulation placed over the waterproofing layer



Concrete laid over insulation to achieve desired slope in terracing.

WINDOWS (EXTERNAL SHADING AND GLAZING)

EXTERNAL SHADING DEVICES

BRIEF DESCRIPTION

A shading device outside window openings is designed to cut-off solar radiation when it is undesirable. Typically, external shading can be in the form of:

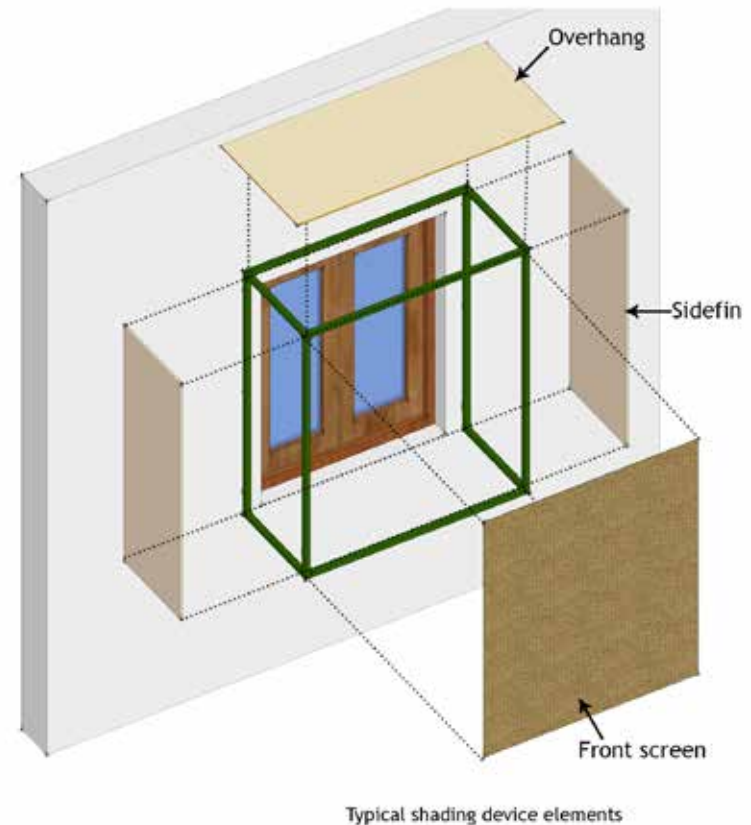
1. Overhang: This is the horizontal projection above window that shields it from direct solar radiation when the sun is at a high altitude, and also protects from rain.
2. Side-fin: This shading element restricts direct solar radiation from the sides when the sun is at a lower altitude. This is often designed as a fixed element.
3. Front screen: The front screen should be a movable/retractable system that allows some light even while shading. The screen can be drawn across the front of the window when the sun is directly facing the window and, it can be retracted or opened when the sun is on the other side.

Overhang and side-fins are generally fixed shading elements while the front screen is often movable.

The ENS code document gives external shading factors (ESF) for overhang and side-fins for different projection factors (PF*). The value of ESF (always <1) reduces as the PF increases and the code document gives ESF values up to a PF value of 1.0; however, this reduction in ESF is not linear in nature. Therefore, often a PF of 0.4-0.5 is used in practice, which yields 65%-85% of the ESF reduction possible with a PF of 1.0 for overhang and side-fins. Going with higher PF (>0.5) will help in further reducing the ESF but the incremental cost would be more. For example, for a typical opening of 1200-mm height and 900-mm width, an overhang of 480-600 mm and side-fins of 360-450 mm would be recommended.

Specific recommendation for overhang, side-fins and front screen is given for each of the eight orientations and for locations above and below the Tropic of Cancer.

* Please refer Eco-Niwas Samhita 2018 code document, Annexure 1 for projection factor, overhang and projection factor, side-fin terminology, and visual depiction.





Cement board Overhang with MS framework



Precast overhang and concrete jaali sidefin



Foldable roll up fabrics



Water-resistant Fabrics can also be used for shading windows



Sliding movable screens with perforations that aids better ventilation



Perforated metal Jali

SHGC EQUIVALENT CALCULATION OF THE WINDOW

An Example

A proposed single storey house in Delhi has a window opening to the West (W2). The glass has an SHGC of 0.80.

Following are the window details:

Window Opening	Opening Width (m)	Opening Height (m)
W2	0.80	1.3

W2 has both overhang and right-side fin shading, where the slab length of overhang is 1.10m and right-side fin is 1.10m from the wall.

The External Shading Factor (ESF) values with respect to the type of shading, latitude, and projection factor can be referred from Annexure 7, Tables 10-15, Page nos 30-35 of ENS 2018.

In order to calculate the SHGC equivalent of the window, the following steps are to be followed:

Step1. Calculating the projection factor (PF) for permanent external projection

External shading Factor for Overhang ($ESF_{overhang}$) for LAT $\geq 23.5^\circ$ N

External Shading Factor for Overhang ($ESF_{overhang}$) for LAT $\geq 23.5^\circ$ N								
Orientation	North (337.6°-22.5°)	North-east (22.6°-67.5°)	East (67.6°-112.5°)	South-east (112.6°-157.5°)	South (157.6°-202.5°)	South-west (202.6°-247.5°)	West (247.6°-292.5°)	North-west (292.6°-337.5°)
$PF_{overhang}$								
<0.10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.10-0.19	0.955	0.930	0.922	0.906	0.881	0.905	0.922	0.930
0.20-0.29	0.922	0.876	0.855	0.824	0.789	0.823	0.853	0.875
0.30-0.39	0.897	0.834	0.796	0.755	0.719	0.753	0.794	0.834
0.40-0.49	0.877	0.803	0.745	0.697	0.665	0.695	0.743	0.802
0.50-0.59	0.860	0.779	0.702	0.652	0.626	0.650	0.700	0.778
0.60-0.69	0.846	0.761	0.666	0.617	0.598	0.614	0.663	0.760
0.70-0.79	0.834	0.747	0.635	0.590	0.580	0.587	0.632	0.746
0.80-0.89	0.825	0.737	0.609	0.569	0.569	0.566	0.606	0.736
0.90-0.99	0.817	0.729	0.587	0.554	0.563	0.551	0.585	0.728
≥ 1	0.810	0.722	0.569	0.542	0.559	0.539	0.566	0.721

(Refer Annexure 7, Page no. 28 for definition and visual depiction)

For W2,

$$PF_{overhang} = \frac{H_{overhang}}{V_{overhang}}$$

$$H_{overhang} = 1.10 \text{ m}$$

$$V_{overhang} = 1.30 \text{ m}$$

$$PF = 1.1/1.3 = 0.84$$

$$PF_{right} = \frac{H_{right}}{V_{right}}$$

$$H_{right} = 1.10 \text{ m}, V_{right} = 0.80 \text{ m}$$

$$PF_{right} = 1.10/0.80 = 1.375$$

Step 2: Select the ESF value for each shading element

Select the ESF value for each shading element from Table no. 10 on Page no. 30 of ENS 2018.

Therefore, $ESF_{\text{overhang}} = 0.606$

External shading Factor for Side Fin Right (ESF_{right} for $LAT \geq 23.5^\circ N$)

External Shading Factor for Side Fin-Right (ESF_{right}) for $LAT \geq 23.5^\circ N$								
Orientation PF_{right}	North ($337.6^\circ - 22.5^\circ$)	North-east ($22.6^\circ - 67.5^\circ$)	East ($67.6^\circ - 112.5^\circ$)	South-east ($112.6^\circ - 157.5^\circ$)	South ($157.6^\circ - 202.5^\circ$)	South-west ($202.6^\circ - 247.5^\circ$)	West ($247.6^\circ - 292.5^\circ$)	North-west ($292.6^\circ - 337.5^\circ$)
<0.10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.10-0.19	0.968	0.942	0.972	0.982	0.961	0.965	0.988	0.985
0.20-0.29	0.943	0.894	0.949	0.968	0.933	0.934	0.977	0.972
0.30-0.39	0.924	0.855	0.931	0.957	0.912	0.907	0.968	0.961
0.40-0.49	0.911	0.824	0.917	0.950	0.898	0.884	0.960	0.953
0.50-0.59	0.899	0.798	0.905	0.944	0.887	0.865	0.954	0.945
0.60-0.69	0.890	0.777	0.895	0.939	0.880	0.849	0.948	0.939
0.70-0.79	0.883	0.762	0.887	0.936	0.875	0.837	0.943	0.934
0.80-0.89	0.877	0.750	0.881	0.933	0.872	0.827	0.939	0.930
0.90-0.99	0.871	0.739	0.875	0.930	0.868	0.819	0.935	0.926
≥ 1	0.865	0.731	0.870	0.927	0.865	0.812	0.932	0.922

$ESF_{\text{right}} = 0.932$ (Refer Table no. 12, Page no. 32 of ENS 2018)

$$ESF_{\text{sidefin}} = 1 - \left[(1 - ESF_{\text{right}}) + (1 - ESF_{\text{left}}) \right]$$

$$ESF_{\text{sidefin}} = 1 - [(1 - 0.932)] = 0.932$$

Step 3: Calculating the total external shading factor (ESF_{total})

(For definition, refer Annexure 7, Page no. 28 of ENS 2018)

Calculating the total external shading factor (ESF_{total}) using the formula:

$$ESF_{\text{total}} = ESF_{\text{overhang}} \times ESF_{\text{sidefin}}$$

$$ESF_{\text{total}} = 0.606 \times 0.932 \\ = 0.56$$

Step 4: Calculating the solar heat gain coefficient ($SHGC_{\text{equivalent}}$)

(For definition, refer Annexure 7, Page no. 28 of ENS 2018)

$$SHGC_{\text{equivalent}} = SHGC_{\text{unshaded}} \times ESF_{\text{total}} \\ = 0.80 \times 0.56 \\ = 0.448$$

EXTERIOR SHADING DEVICE MATERIAL OPTIONS

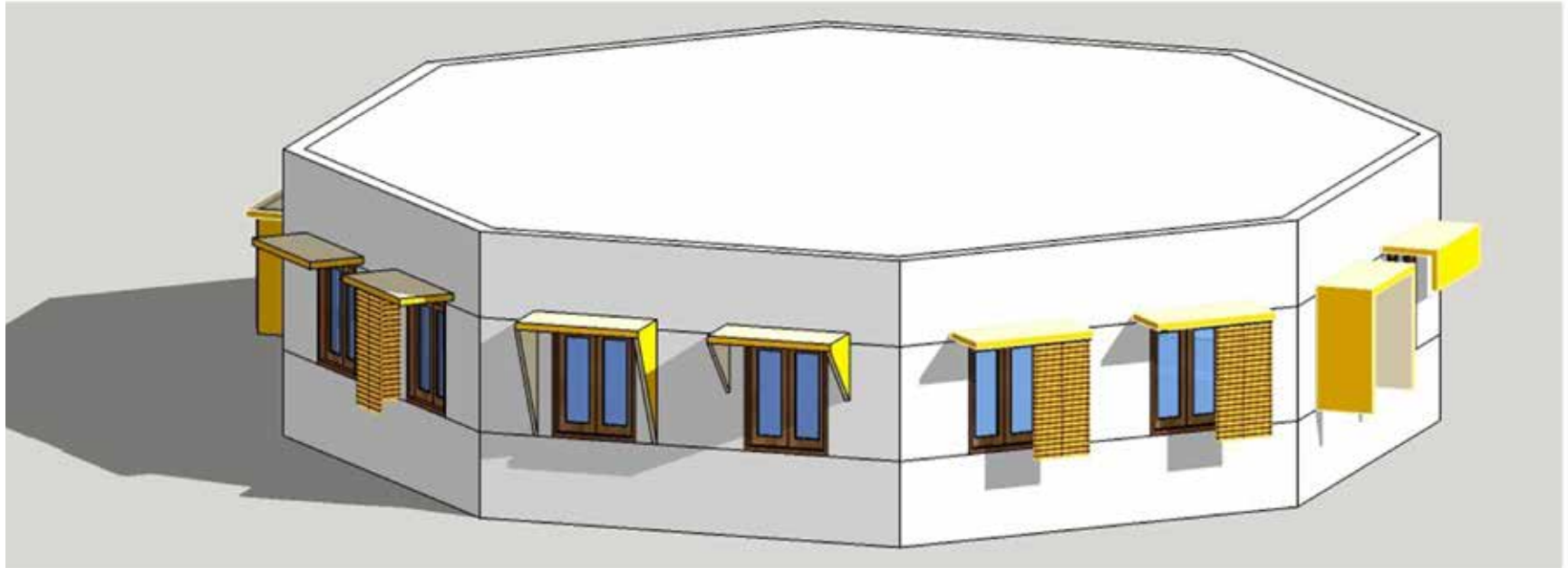
BRIEF DESCRIPTION

The solar heat gain for non-opaque surface/windows can be minimised by external shading devices. Shading devices can either be horizontal or vertical. Horizontal shade is ideally installed just above the window at lintel level, and vertical fins could be placed on either side depending on the direction of the sun.

There are a number of materials that can be used to block the solar radiation depending on the functionality, aesthetic form, and ease of use in the form of shading devices.

1. Overhang: Materials such as cement board, fibre glass sheet, ferrocement, precast concrete panel, chajjas made of RCC, and stone are used for overhangs. Some of these materials will require a framework to support the overhang.
2. Side-fin: Side-fins could be made from cement boards, perforated metal sheet, punched louvre GI panel, concrete/GRC jaali, WPC boards, bamboo, welded MS flats or a weather-resistant fabric. Some of these materials will require a frame to provide a structure to the side-fin.
3. Front screen: Vertically suspended lightweight materials such as bamboo chiks, foldable fabrics (ferrari), cloth, and GRC panels can be used as front screens.





Different forms of shading devices elements that can either be placed horizontal or vertical. Shading elements are designed depending on the orientation and exposure from the sun.

TYPICAL SHADING DEVICE FRAMEWORK

BRIEF DESCRIPTION

If a projected frame of light metal section is fixed on the wall surrounding the window opening is provided (as shown in the wall section), it will help to attach the shading panels or screens conveniently. This frame would allow the user to easily install shading screens/chiks/ cloth, etc. These screens can be either fixed or movable type. The extent of the shading panel would depend on the orientation of the window. (See illustrations)

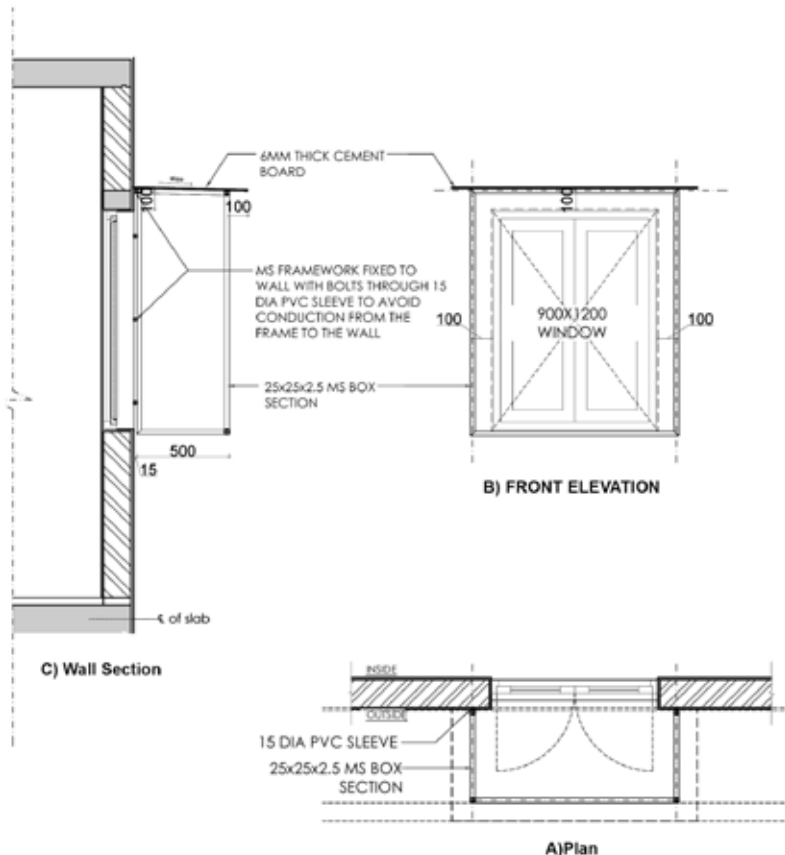
Framework: The framework is a support system designed to easily fix shading screens corresponding to the orientation. This typical box frame is made up of MS sections; other alternative options include aluminium, stainless steel, and GI. However, the box frame cost is provided for MS section.

The chhajja projection at the top should ideally be a lightweight, non-porous material such as cement board. One may also use stone or any other waterproof boards. The frame should be attached to the external wall with minimum surface area in contact with the wall. PVC sleeves can be used to separate the frame and wall and limit the conduction heat gains from the shading device to the envelope.

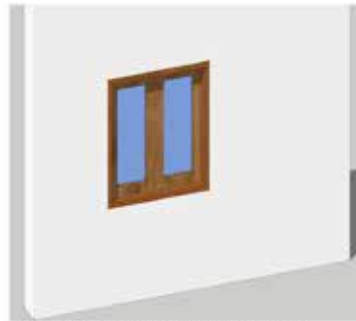
The fixed shading elements may be provided by the builder at the time of making the building, whereas roll-up/pull-down screens may be left to the user to install. Figure A provides the sketch of the assembly. The construction steps are shown in Figures 1 to 4. The details of the front elevation and wall section are shown in Figures B and C, respectively.



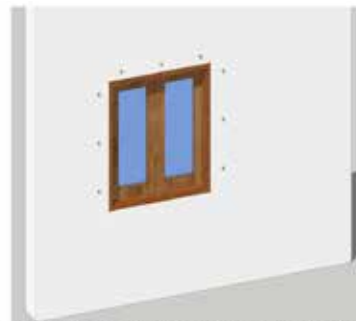
₹3000
Cost/m²



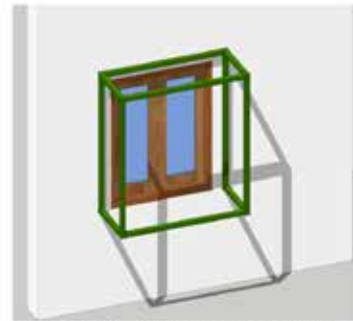
CONSTRUCTION STEPS



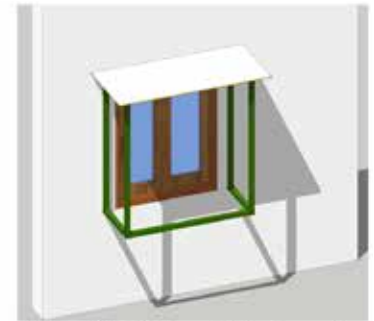
1 Taking the case of 900x1200mm standard window



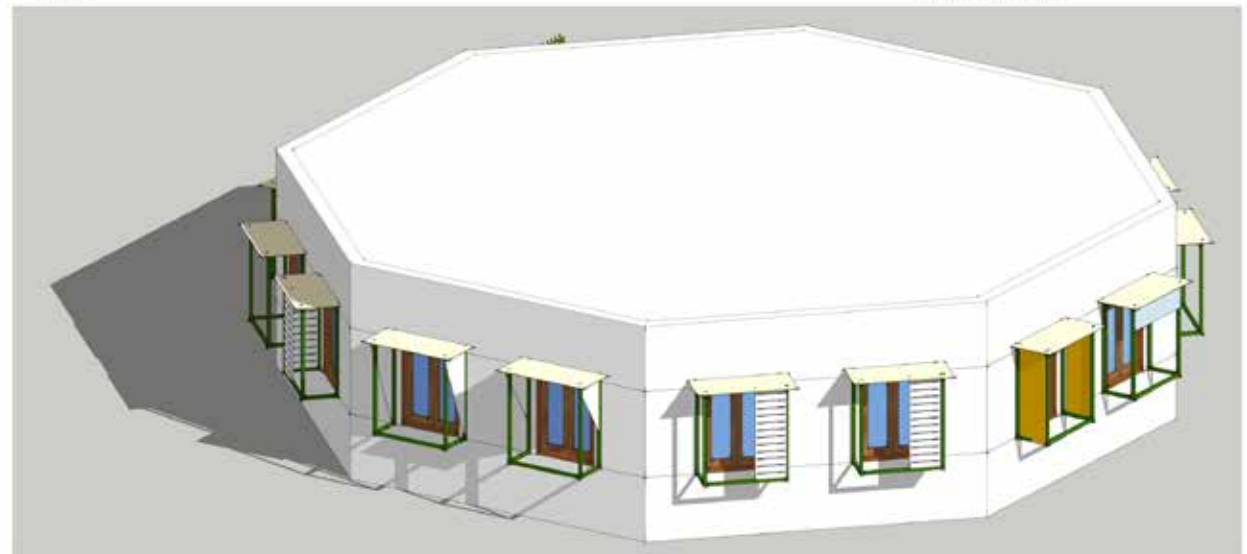
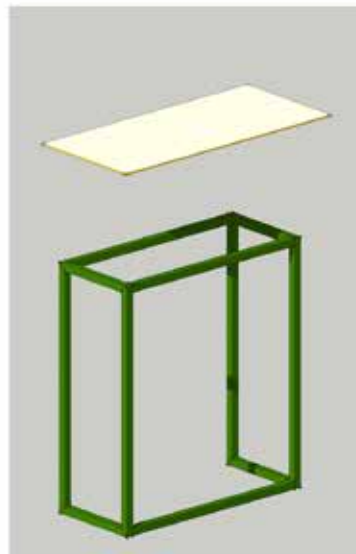
2 Drill holes, fit PVC sleeve that project out by about 15 mm and align them in one plane.



3 Fix the MS box frame with bolts, each frame can come separately and bolted.



4 Once the MS frame is fixed properly, different shading devices can be installed over it.

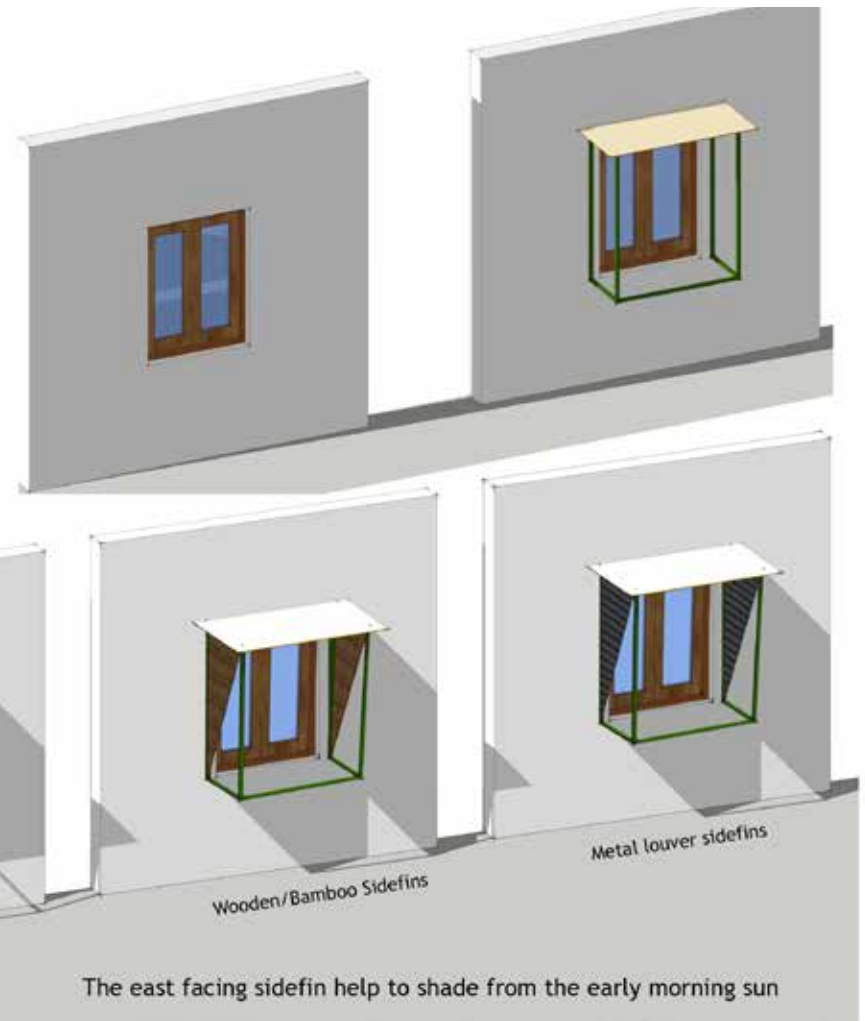


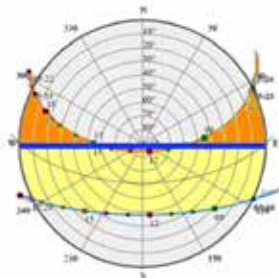
The shading device acts as a framework to further fix shading screens, chiks, perforated panels etc. depending on the orientation of the facade.

SHADING IN NORTH FAÇADE

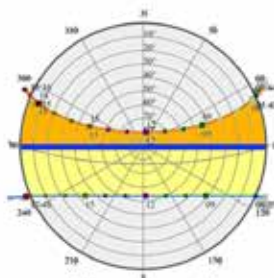
FOR LATITUDES ABOVE THE TROPIC OF CANCER

The northern façade in northern latitudes of India receives direct solar radiation only in the extreme summer months, during early morning hours, and late afternoon hours. Ideally, vertical fins on the eastern and western sides of the window are provided to shade the window during these periods. However, as the angle of incidence of solar radiation on a northern façade is oblique and the impact of this radiation is relatively small, the vertical fins may be sacrificed.





Delhi sun path
Sun exposure for North facing window

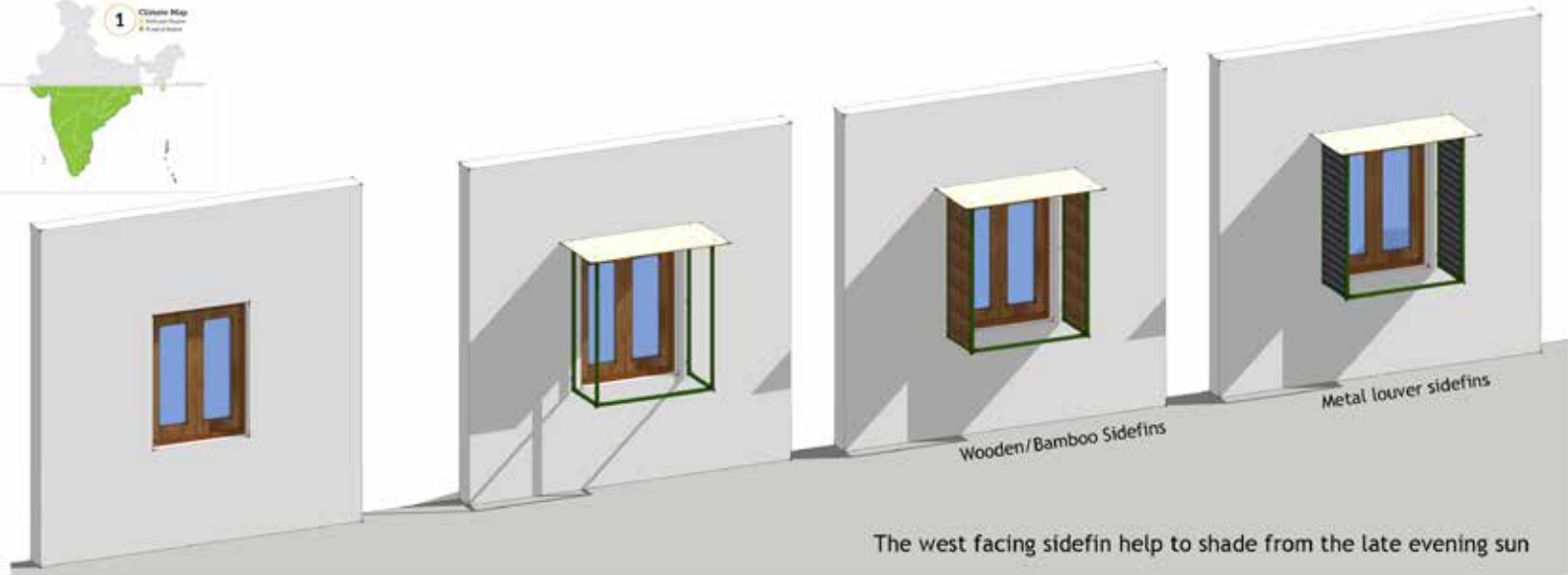


Chennai sun path
Sun exposure for North facing window



FOR LATITUDES BELOW THE TROPIC OF CANCER

The northern façade in southern latitudes of India, however, is exposed to direct solar radiation during the morning and evening hours for a much longer period of the year, as compared to the exposure in northern latitudes. Also, the angle of incidence of the sun's rays on the façade is less oblique and more impactful. Hence, it is necessary to provide vertical fins on the eastern and western sides of the window in addition to the horizontal overhang above the window.

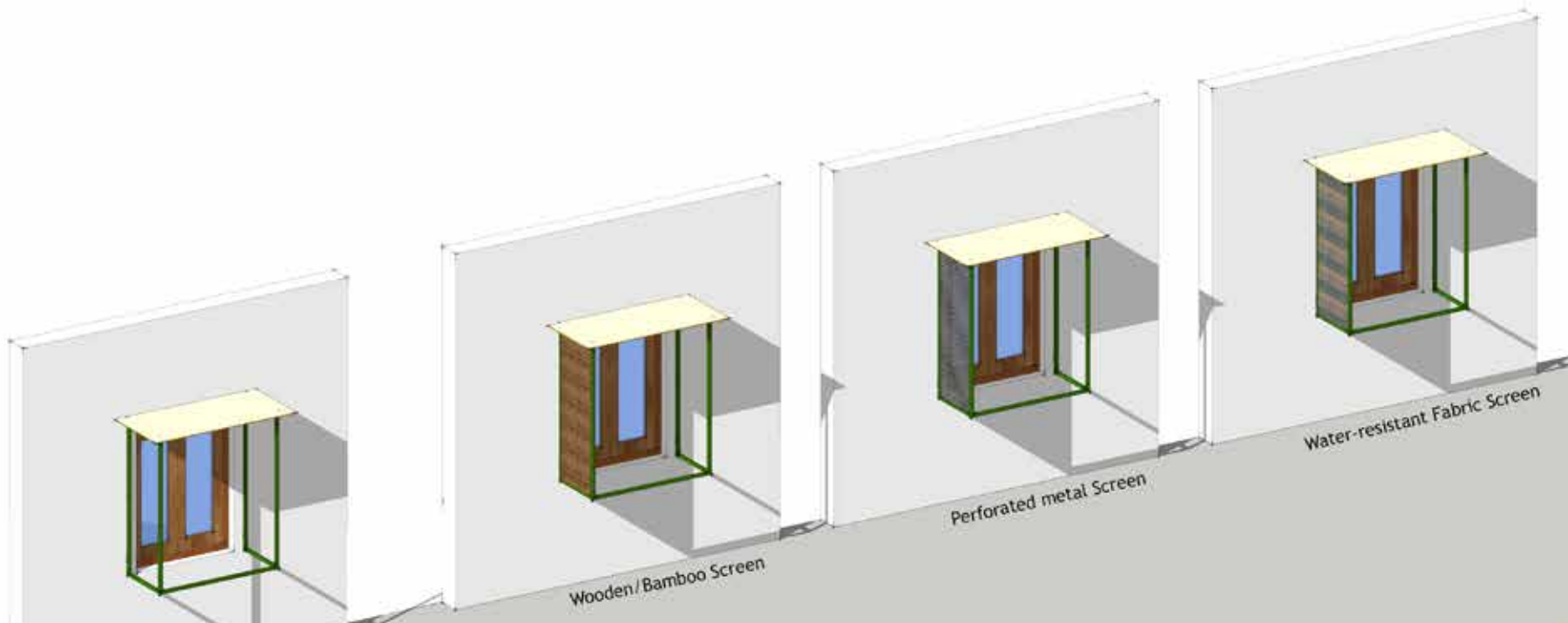


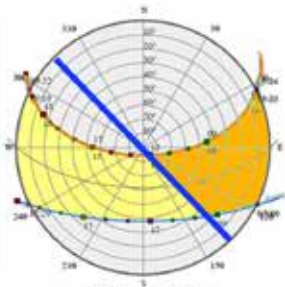
The west facing sidefin help to shade from the late evening sun

SHADING IN NORTH-EAST/NORTH-WEST FAÇADES

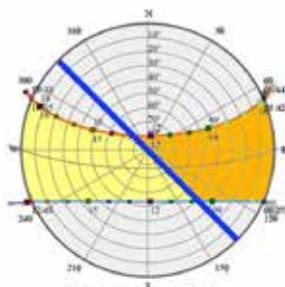
The north-east and north-west façades face the rising and the setting sun, respectively, during the hottest part of the year. The sun angle is low and thus it leads to direct solar radiation into the building. This is most critical for the north-western façade as the ambient temperature is already high in the afternoon.

This can be dealt with by putting fixed screens/shutter across the face of the window as shown in these images. The screen can have slits or perforations on 15%-20% of the surface area. This would allow for better ventilation, while blocking 80% of direct solar radiation. The perforations and slits also help in dissipating the heat that the screen itself would absorb and re-radiate towards the window.

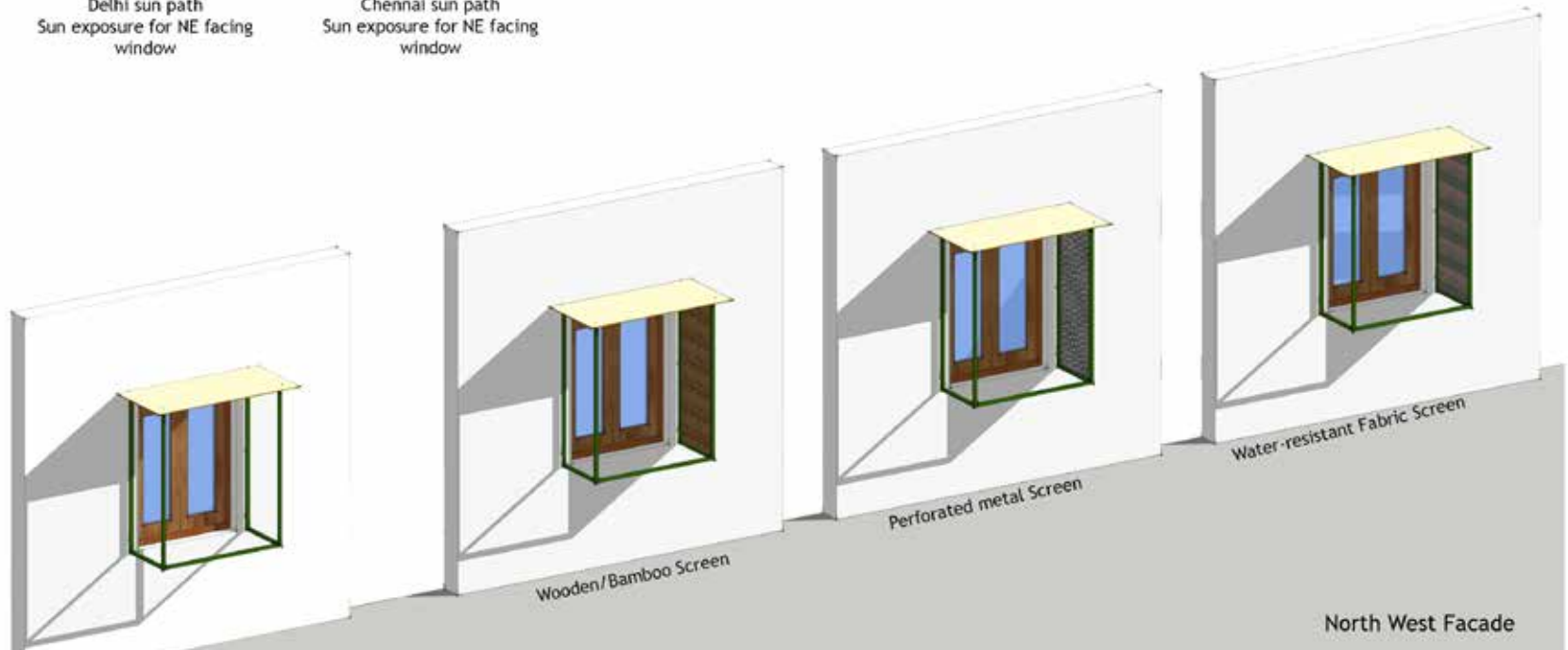




Delhi sun path
Sun exposure for NE facing
window



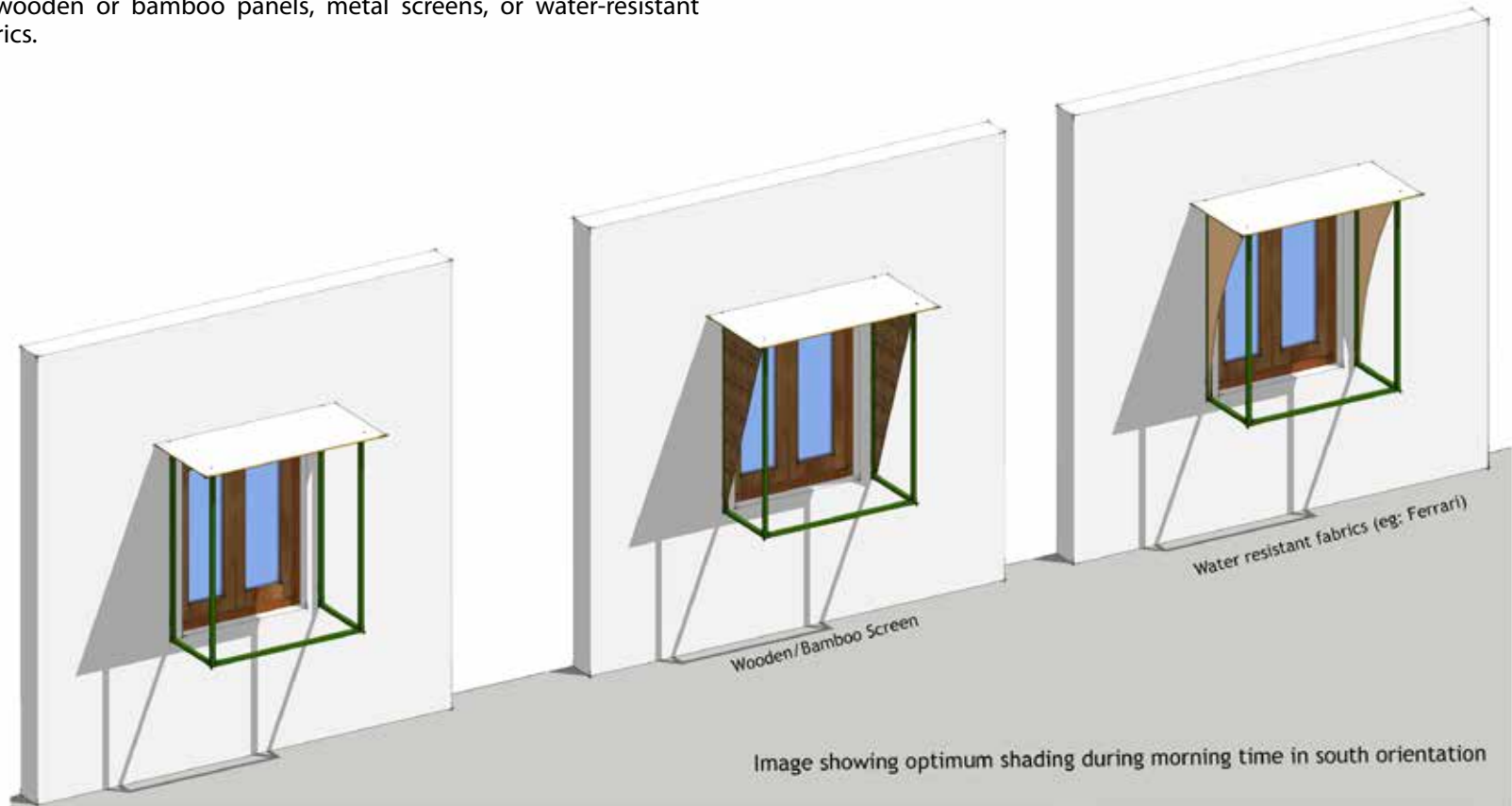
Chennai sun path
Sun exposure for NE facing
window

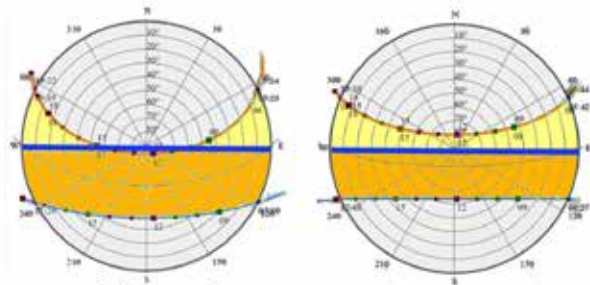


North West Facade

SHADING IN SOUTH FAÇADES

The southern façade faces the sun for the longest period. Here, the overhang above the window plays a major role in cutting the solar radiation. The vertical fins on either side of the window cut off the direct solar radiation of the early morning and late afternoon. These fins could be of a triangular shape as shown. They can be made out of wooden or bamboo panels, metal screens, or water-resistant fabrics.





Delhi sun path
Sun exposure for South facing
window

Chennai sun path
Sun exposure for South facing
window

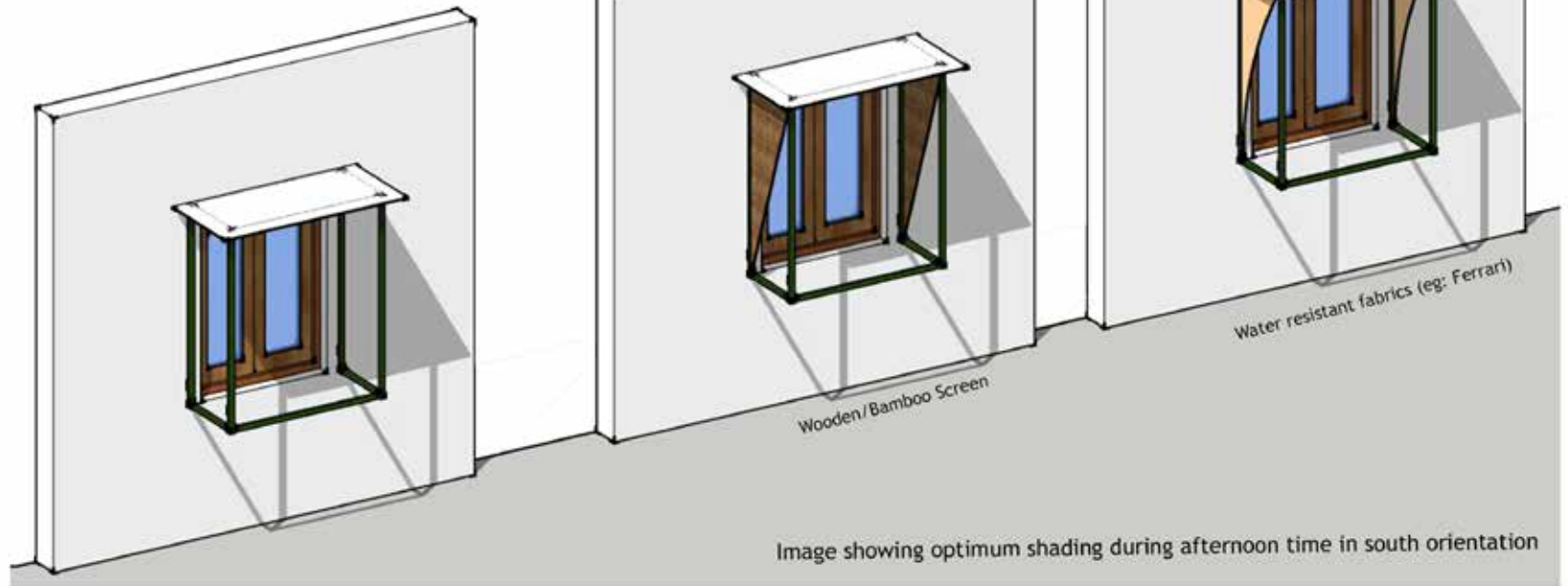


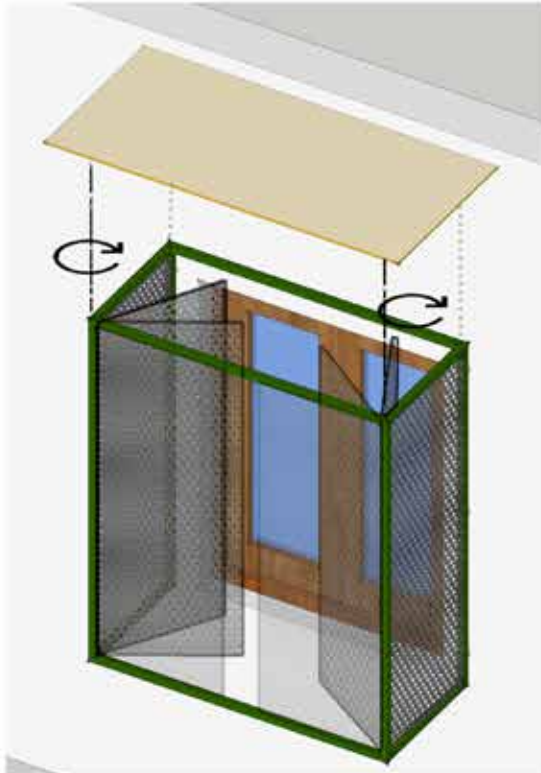
Image showing optimum shading during afternoon time in south orientation

SHADING IN EAST/WEST FAÇADES

The east and west façades are exposed directly to the strong radiation of the sun for the entire morning on the east face and for the entire afternoon on the west face. Thus, the sun penetrates deeper directly from the front

of the window. The east-facing window needs protection from the sun during the morning half of the day. The west-facing window needs to be protected during the afternoon half of the day. Thus, a screen or shutter is necessary

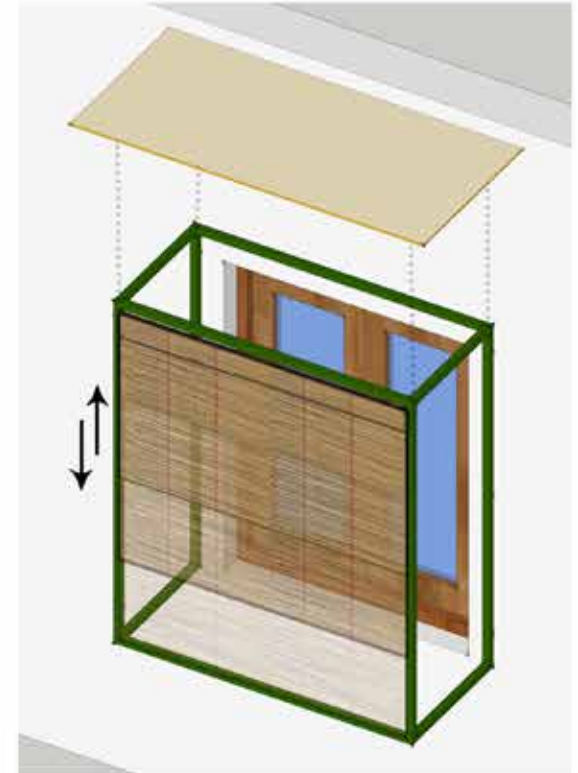
across the face of the window to block the direct solar radiation. As this is necessary for only half of the day, a good solution is to have a movable shading system across the face of the window.



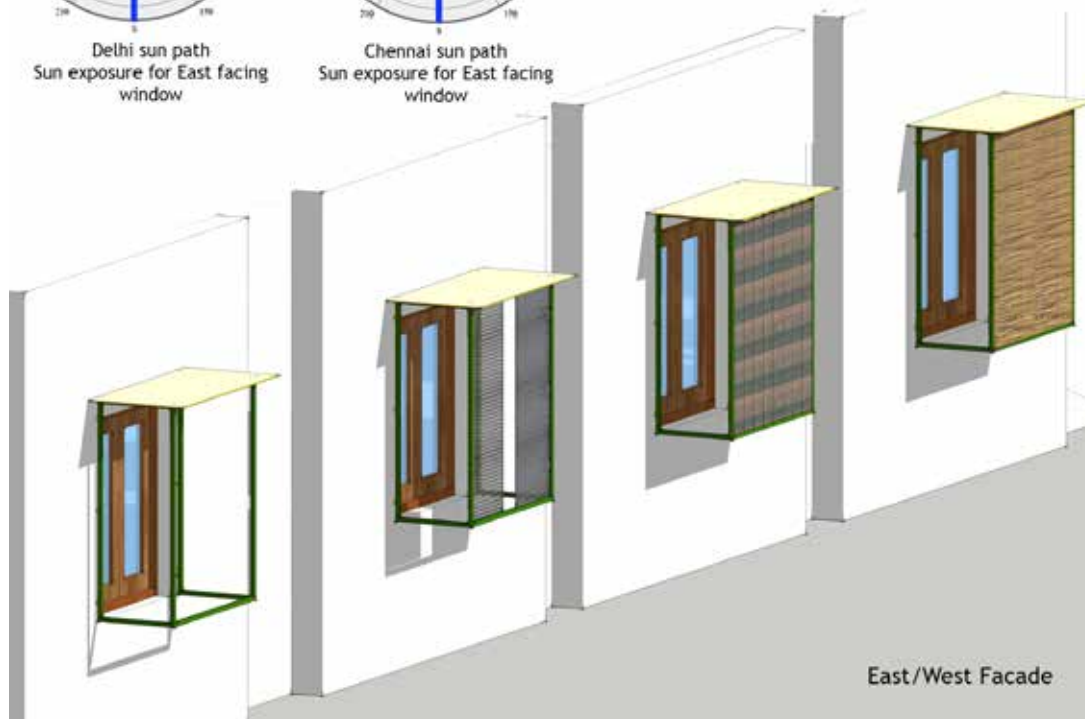
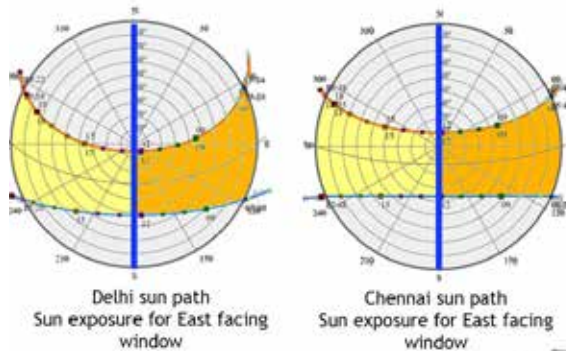
a) Hinged or pivoted type



b) i) Sliding/Folding type



b) ii) Roll-up/Roll-down type



This may be achieved through the following ways:

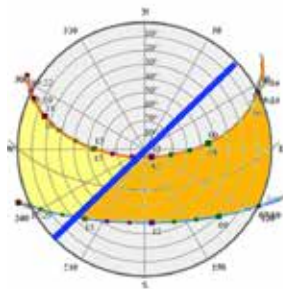
- a) **A hinged or pivoted** shutter with optimum size perforations/cut-outs/openings, etc. can be made of various materials such as the following:
 1. Punched galvanised steel louver panel
 2. Painted louvre wooden panel
 3. Perforated metal/plastic screens
 4. Water-resistant/WPC boards
 5. Treated bamboo chiks
- b) **A retractable** system with a breathable and translucent membrane could be further classified in two categories.
 - i) **Sliding/Folding (horizontal movement)**
Here, stretchable, durable, and abrasion-resistant nylon and polyester fabrics/curtains can be slid along two rods fixed on top and bottom of the fabric.
 - ii) **Roll-up/roll-down (vertical movement)**
Here, materials like bamboo chiks, foldable fabrics (ferrari), and cloth could be used.

SHADING IN SOUTH-EAST/SOUTH-WEST FAÇADES

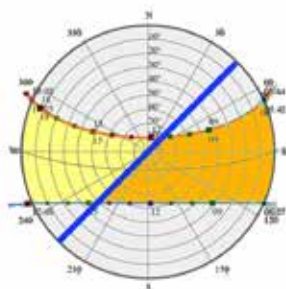
The south-east and south-west façades are exposed to both the lower altitude sun and the overhead sun. Thus, it gets solar radiation from both sides and front. So, it is necessary to have a shading provision on sides and front as well. This could be achieved by having fixed side-fins and a movable front screen. Movable shading screens can operate in the following ways:

- A) A hinged/pivoted system
- B) A retractable system
 - a. Sliding/folding screen
 - b. Roll-up/Roll-down.

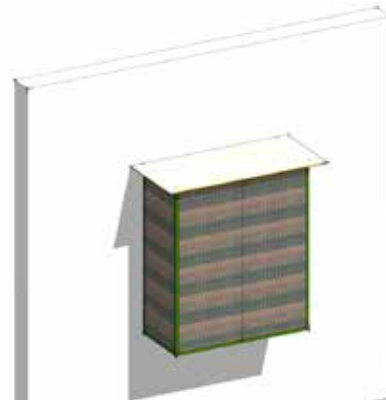
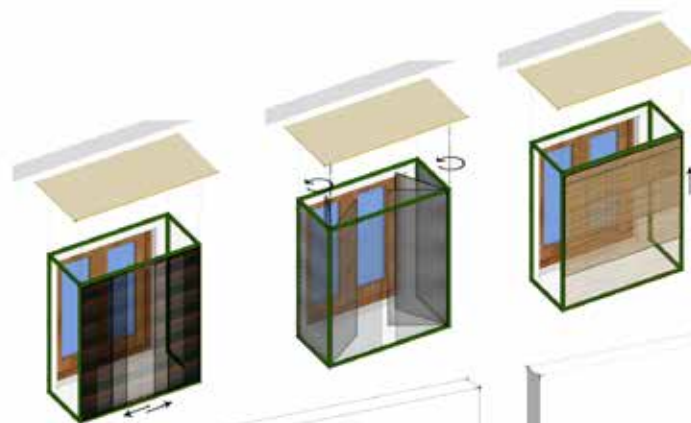




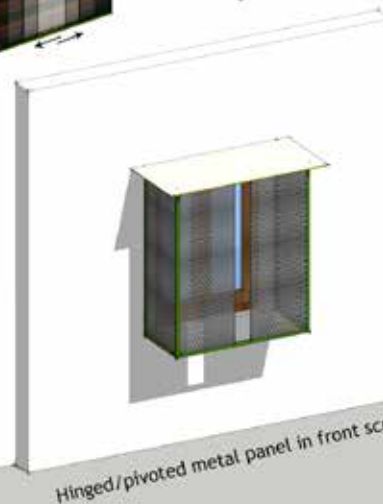
Delhi sun path
Sun exposure for SE facing
window



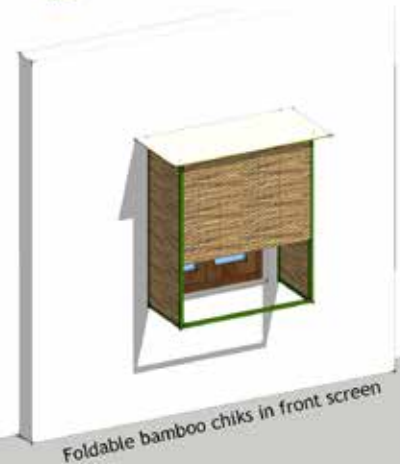
Chennai sun path
Sun exposure for SE facing
window



Sliding/folding fabrics in front screen



Hinged/pivoted metal panel in front screen



Foldable bamboo chiks in front screen

A movable front screen allows for the flexibility to shade the window as required and reduce solar heat gains.

EXTERNAL GLAZING OPTIONS

BRIEF DESCRIPTION

Glazing (non-opaque surfaces) used in window openings allows solar radiation to penetrate inside the space, which results in considerable amount of heat gain. Non-opaque surfaces in windows can trap the heat inside the space due to which the inside temperatures can sometimes be greater than the ambient temperatures.

Therefore, along with designing optimum openings where glazing area should be reduced as per requirement and providing adequate shading devices, it is also recommended to use a better performing glazing. These glazing options have a low U-value and low SHGC, which reduces the heat gain through window conduction and window transmittance, respectively.

Within the building envelope solution sets, the commonly used glazing options for residential buildings are provided.

Technical specifications and terms commonly used for glass

U-value:

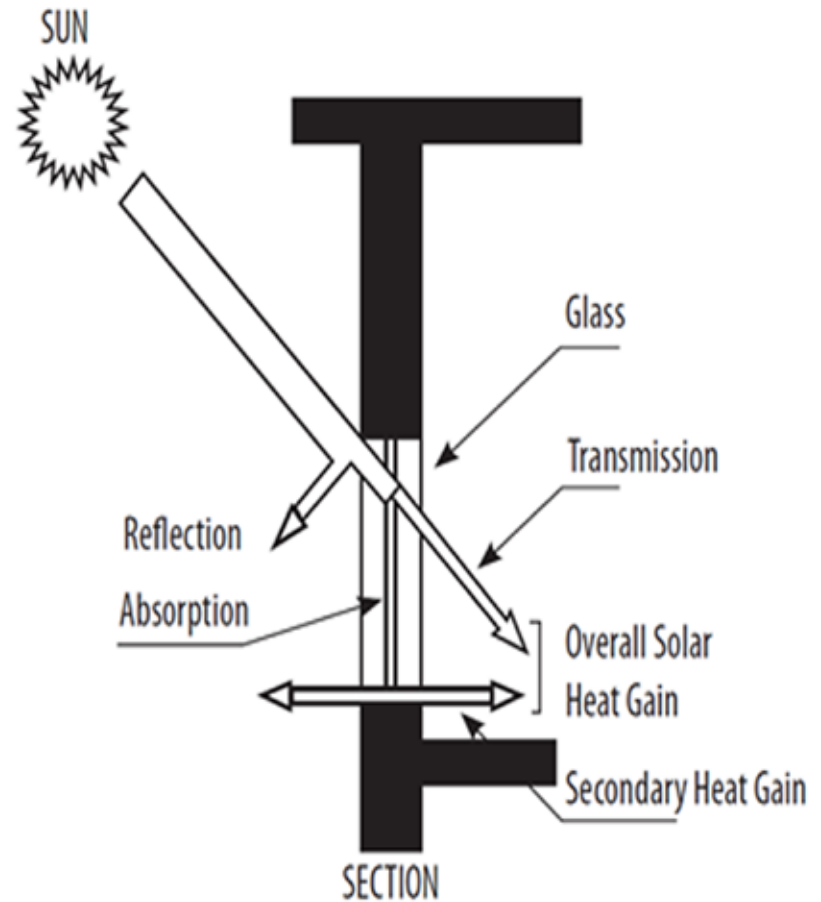
Thermal transmittance (U value) is the heat transmission in unit time through unit area of a material or construction and the boundary air films, induced by unit temperature difference between the environments on either side. Unit of U-value is $W/m^2.K$. The U-value for a wall/roof/glazing indicates its ability to transfer heat through conduction.

Solar factor/Solar heat gain coefficient:

Solar heat gain coefficient or SHGC is the fraction of incident solar radiation admitted through non-opaque components, both directly transmitted, and absorbed and subsequently released inward through conduction, convection, and radiation (Figure on the right).

Visible light transmission:

Visible light transmission (VLT) is the ratio of the total transmitted light to the total incident light. It is a measure of the transmitted light in the visible portion of the spectrum through a material.



SHGC of a glass

TECHNICAL SPECIFICATIONS OF THE EXTERNAL GLAZING OPTIONS

Technical specification	Single clear glass (Baseline)	Single reflective glass	High performance glass (Range as per CPWD DSR 2019)
Uglass (W/m ² . K)	5.8	5.0 - 5.6	3.0 - 3.3
SHGC	0.82	0.4 - 0.5	0.21 - 0.24
VLT (%)	88.1	35 - 50	25 - 35

Cost of Single Clear glass*	
Casement window double panels	Two track two panels sliding window
₹10350/m²	₹8350/m²

Cost of Single Reflective glass#	
Casement window double panels	Two track two panels sliding window
₹10650/m²	₹8650/m²

Cost of High Performance Glass*	
Casement window double panels	Two track two panels sliding window
₹10850/m²	₹8850/m²

*All cost per m² specified above are inclusive of standard uPVC framing cost and are referred from CPWD 2019 DSR.
#Typically, the cost of single reflective glass is ~300 Rs./m² higher as compared to single clear glass.

About Building Envelope Solution Sets

This ready-reckoner set of solutions is made to facilitate the implementation of the *Eco-Niwas Samhita 2018, Part I: Building Envelope*. It contains details of external wall construction, roof construction, and window shading to help meet the Residential Envelope Transmittance Value (RETV) and roof U-value requirements for composite, hot-dry, warm-humid, and temperate climatic zones. Each solution set gives a brief description of the construction assembly, its detailed drawings, steps of construction, technical specifications, and cost analysis as per CPWD's Schedule of Rates 2018.

About Bureau of Energy Efficiency

Bureau of Energy Efficiency (BEE) is a statutory body under the Ministry of Power, Government of India. It assists in developing policies and strategies with the primary objective of reducing the energy intensity of the Indian economy. BEE coordinates with designated consumers, designated agencies, and other organizations to identify and utilise the existing resources and infrastructure in performing the functions assigned to it under the Energy Conservation Act.

About the Indo-Swiss Building Energy Efficiency Project

The Indo-Swiss Building Energy Efficiency Project (BEEP) is a bilateral cooperation project between the Ministry of Power, Government of India, and the Federal Department of Foreign Affairs of the Swiss Confederation. The overall goal of the project is to reduce energy consumption in new commercial, public, and residential buildings in India through energy-efficient and thermally comfortable design. The project has four key components: building design, building technologies, building policy, and outreach.

For further information



Bureau of Energy Efficiency
Ministry of Power, Government of India
4th Floor, SEWA Bhawan
R. K. Puram, New Delhi - 110 066 (INDIA)
Website: www.beeindia.gov.in

Project Management and Technical Unit
Indo-Swiss Building Energy Efficiency Project
Telefax: +91 11 45535574
Email: pmtu@beepindia.org
Website: www.beepindia.org



Ministry of Power has launched Eco-Niwas Samhita 2018 or Energy Conservation Building Code for residential buildings (ECBC-R), Part I: Building Envelope on 14 December 2018. The code defines provision for building envelope to reduce heat gain/loss and improve natural ventilation and daylighting potential.

This document contains solution sets for four climatic zones (composite, hot-dry, warm-humid and temperate) to help meeting code requirements on reducing heat gains from building envelope. It contains details of external wall construction, roof construction and window shading to help meeting the Residential Envelope Transmittance Value (RETV) and U-value requirement of the code.

These ready reckoner set of solutions are made to facilitate the implementation of the code. These solution sets are developed considering the real life practice and have already been implemented in past projects. Each solution set gives a brief description of the construction assembly, its detailed drawings, steps of construction, technical specifications and cost analysis as per CPWD's building schedule of rates 2019.

For further information



Bureau of Energy Efficiency
Ministry of Power, Government of India
4th Floor, SEWA Bhawan
R. K. Puram, New Delhi - 110 066 (INDIA)
Website: www.beeindia.gov.in

Project Management and Technical Unit
Indo-Swiss Building Energy Efficiency Project
Telefax: +91 11 45535574
Email: pmtu@beepindia.org
Website: www.beepindia.org

